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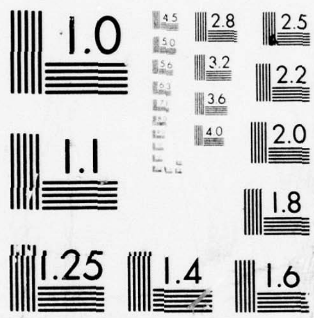

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THE SHOCK AND VIBRATION DIGEST

Volume 10 No. 3
March 1978

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THE SHOCK AND VIBRATION INFORMATION CENTER

Code 8404 Naval Research Laboratory
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DIRECTOR NOTES

The voluntary standards system in the United States is extremely complex. When one considers this complexity, it is not surprising that there are a number of problem areas relating to the system. Among the problems that require attention are the need for improving the coordinating force in the system, the lack of a single set of national standards, and the need for a firm policy on standardization by the government.

With respect to the latter, the Office of Management and Budget (OMB) issued a circular on January 13, 1978 which seems to be a step in the right direction. The subject of the circular is "Interaction with Voluntary Consensus Standards-Developing Bodies." This circular establishes policy for government agencies which work with the voluntary standards system and for those agencies which consider the adoption and use of voluntary standards in lieu of, or in addition to, government standards. In my opinion two items are addressed in the circular that are important to federal employees. OMB endorses the participation of federal employees in voluntary standards activities if it is in the best interest of their agencies and permits financial support of these activities if such support furthers the mission of the agency involved.

Before this issue of the DIGEST is distributed, a symposium on Nongovernment Standards will have been held in Washington. This symposium addresses the benefits to DoD and industry of coordinated development and use of nongovernment standards, and looks at some of the problems involved in such efforts. It is my hope that this conference will have produced some useful results.

Old friends of SVIC will be saddened to hear of the death of Kay Jahnel. Until 1971, Kay had served the Center well for about twenty years. During this period she made many friends. We extend our deepest sympathy to her family.

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EDITORS RATTLE SPACE

LITERATURE REVIEW*

How often have you tried to find information about an unfamiliar technical area and become frustrated, either because you can't find anything or because the quantity of material you come up with -- relevant or not -- is overwhelming. Even after you eliminate the irrelevant material, how do you know if what you have is the best available or if it applies to your problem.

The purpose of the DIGEST literature review is to help you with these problems. It is the goal of the DIGEST staff to provide reviews that are subjective critique/summaries of papers, reports, patents, and proceedings pertinent to a topic in the shock and vibration field. The field now encompasses an impressive 150 topic areas. This means that each topic is reviewed once every three years. Technical topics are assigned to shock and vibration experts who monitor the theoretical and technical progress of their area as part of their research activities.

The literature review section complements the objective presentation of shock and vibration literature found in the ***Abstracts from the Current Literature*** section of the DIGEST. The literature review should stress important recent technology so that established engineers can keep abreast of developments in a technical area; new investigators can become acquainted with an area in a short time; and interested persons can learn about a technology without major study. The most useful literature review should therefore include the following: a minor tutorial of the technical area under discussion, a survey and evaluation of recent literature, and recommendations for future research. Each literature review should be basic, explanatory, and complete. Only pertinent literature should be cited -- it is useless to reference work that does not contribute to the understanding of or show the progress in a technology.

It might be reasonable to ask how an article can be written for both the expert and the casual reader. First, we expect the casual reader to have no more than a basic knowledge of shock and vibration -- hence, jargon must be minimized -- or the words clearly defined -- if this reader is to be drawn into the article. On the other hand, the article should be of interest to the expert if the material is presented in a conceptual way and adequately referenced so that he can find detailed information.

Illustrations are encouraged and detailed mathematics discouraged in review articles. Physical phenomena and mathematical techniques can generally be described with simple mathematics. It is more instructional to show how a variable depends on prescribed parameters than to present a series of complex formulas or derivations of expressions that must be worked out by the reader.

Such goals present the reviewer with a formidable task. However, if he will select, evaluate, and describe the literature according to the objectives described above, the DIGEST staff will edit and style the material -- defining obscure words and clarifying difficult concepts when necessary -- so that the literature review articles will be interesting and worthwhile to all readers.

The DIGEST is now seeking new reviewers -- particularly in testing and design. If you are interested, please write me for details.

R.L.E.

***This is the first of a series of editorials on the purpose of various sections of the DIGEST**

RIDE AND HANDLING DYNAMICS OF ROAD VEHICLES (A REVIEW OF RECENT LITERATURE)

F.D. Hales*

Abstract - This is a brief review of road vehicle ride and handling dynamics since 1975. The literature is grouped as follows: ride quality, including vehicle design, measurements of quality, human response to motions, and evaluation techniques; and handling, including tires, bicycles, automobiles, and trucks. The article concludes with a discussion of trends in vehicle ride and handling dynamics.

This paper is a review of ride and handling dynamics of road vehicles since 1975. A brief overview of work in ride and handling dynamics of road vehicles is followed by a more detailed consideration of recent contributions in ride and handling and a general consideration of work currently being reported.

BACKGROUND

Ride quality of road vehicles has always been primarily concerned with vertical motions and their effects on occupants and cargo. Maintenance of vehicle integrity has tended to be one aspect of structural and service stress design.

Motion studies began with simple models of rigid body and wheel motions [1]. Early work on the effect of vehicle motion on people includes that for German railways [2].

A movement begun during the 1960s to develop 'standards' for vibration exposure has split into two factions: one concerned with developing and defining an international standard, and a second concerned with attempts to more fully understand human reactions to vibration. The first faction has produced ISO 2631 [3] and the second group a range of interesting papers; see Pradko and Lee [4], for example.

Vehicle handling has interested automobile engineers since 1907, when Lanchester [5] first coined the term "oversteer." Progress was slow during the next 50 years, with some exceptions, e.g., the development of tire slip theory by Broulhiet [6] and Olley's contribution [1]. A contract from General Motors to the Cornell Aeronautical Laboratory for studies in vehicle handling in the 1950s led to the publication of a set of papers [7]. Soon after, groups involved in vehicle handling were developed at a number of centers around the world. Significant papers now appear from the U.S., the UK, most European countries - especially Germany, France, and Sweden - Japan, and Australia. Not surprisingly such worldwide interest has produced both progress and repetition.

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RIDE QUALITY

Recent publications on ride quality are considered under four headings: vehicle design, measurement of ride quality, experimental studies in human response to vibration, and techniques for evaluating ride quality.

Vehicle design. Four of the six papers on vehicle design are concerned with optimization of ride quality: the benefits of rubber-air damping devices [8], the effect of tertiary suspension using cab suspension [9], and sophisticated computer-based evaluation procedures for optimization of ride quality and suspension design [10, 11]. The other two papers are concerned with the anti-dive behavior (pitch) of suspension systems [12, 13]. Ellis [12] developed a mathematical model; he used 'suspension derivatives' to predict pitch and bounce motions during braking. Metz [13] explored the possibilities of variable anti-dive suspensions in vehicle design.

Measurement of ride quality. Jennings [14] attempted to correlate improved subjective performance of various motor cycles with objective studies of their suspension systems. An electro-hydraulic simulation facility for truck ride studies with a sophisticated input control system has been described [15]. Griffin [16] reviewed ride quality studies in the United Kingdom dating from 1960 to 1974.

Human response. Experimental studies in human response to vibration represent progress toward a

full understanding of ride phenomena. Six of the seven papers published since 1975 were presented at the 1975 Ride Quality Symposium held by NASA. The relationship between vibration measurements and subjective ratings -- the crux of the ride quality problem -- was studied [17]. In a classical comfort study, comfort was related to acceleration magnitude [18]. Both Clark and Oborne [19] and Klauder and Clevenson [20] presented some preliminary conclusions of interesting work on the techniques available for quantifying subjective assessments. Multi-axis excitation was studied with a narrower base than most workers use [21]. The results indicated that lateral vibration can complicate vertical acceleration reactions. Again from a controlled narrow experimental base, Jones and Rao [22] showed that ISO 2631 has some defects, even for sinusoidal vibrations, and Dempsey and Leatherwood [23] came to the same conclusion after studies at the NASA ride test facility.

Evaluation techniques. The major effort on ride quality had to do with ride evaluation techniques and procedures. The NASA program on ride quality has been outlined and results of the program reported [25, 26]. Lee [26] also studied the problems involved in quantifying human reactions to vibrations. Vehicle motions are the product of road input and vehicle characteristics. Both simple [27] and stochastic [28] approaches have been applied to the quantification of road input. Wambold and Park [29-31] are developing a measuring system based on a modified Pradko, Lee approach and used an interesting quasi-marketing approach in their report.

The remainder of the papers are concerned with criteria and standards, a subject that has been written about to the extent that the word saga seems appropriate. The most recent papers should be read, but readers new to the subject should be aware that all nuances cannot be appreciated immediately. The review by Stikeleather [32] provides some general background. Von Gierke [33] propounds the background of and need for ISO 2631. Allen [34] sounds some notes of caution, and Janeway [35, 36] strongly attacks some of the more fragile hypotheses incorporated in ISO 2631.

HANDLING DYNAMICS

Recent publications on handling dynamics are also considered under four headings: tires, bicycles, automobiles, and trucks. Single wheel studies comprise almost half of the published work since 1975.

Tires. These papers have to do with tire forces and single-wheel dynamics. For a given tire and road having a specific surface condition as well as lubrication by water, tire-road interface forces at moderate speeds are in general considered as nonlinear functions of pressure, previous tire history (both short and long-term), longitudinal and lateral slip, camber angle, and vertical load. Fortunately the operating conditions often allow simplifying assumptions.

Krauter [37] tackled the problem of truck tire forces by optimizing a simulation behavior with respect to a real truck. Within limits the process is satisfactory, but the technique seems likely to be favored only by "truck-buffs."

Studies of tire frequency response produce interesting papers, and those of Weber and Perch [38, 39] and Shuring and Gusakov [40] are no exception. These authors are concerned with the effect of tire frequency response on vehicle dynamics. The papers contain useful test data on tire frequency response. Weber and Perch also predicted the effects on vehicle behavior of the frequency response, and Shuring and Gusakov published experimental results.

The complex behavior of tires is well illustrated in a number of papers [42-46]. Lippmann and Oblizajek [41] studied the effects of wear on tire behavior by noting the changes in tire performance resulting from significant tread wear. Phelps et al [42] studied tire behavior during the initial breaking-in and settling down process that is so essential before consistent performance measurements can be made. Gerresheim and Hussmann [43] reported longitudinal slip studies and movements within the contact patch. Tire uniformity is a continuing quality control problem. Grins [44] reported on a computer-assisted -- part of the control and the data processing -- machine. The effect of drum speed and curvature on tire forces was also studied [45]. Koch's [46] report on the prediction of tire forces represents the end point of a long program of empirically-based mathematical tire modeling.

Bicycles. The second area has to do with two-wheeled vehicles. The first reference [47] is a conference proceedings; one session contained four papers pertaining to motorcycle handling dynamics. Weir used a control engineering approach similar to one he used in automobile work. Ellis and Hayhoe [47] reported a correlation between predicted and measured steady-state and transient motorcycle behavior. They achieved good agreement in some cases. Another paper [47] dealt with a digital simulation of high-speed behavior; the simulation has been validated experimentally. A primary objective of the study was to investigate high-speed weave instability. Eaton and Segel [47] looked at the lateral dynamics of the uncontrolled motorcycle and achieved reasonable agreement between experiment and analogue simulation. Sharp [48] reviewed the current state-of-the-art in motorcycle dynamics and concluded that more sophisticated tire models must be developed before motorcycle dynamics will be understood.

Four-wheeled vehicles. Four-wheeled vehicles were also studied. Three papers were concerned with stability [49-51]. Celeri and Chiesa [49] discussed tire forces and their measurement as well as methods for analyzing path motions from steering pad tests during evaluations of stability. One critical area of handling has been behavior under extreme conditions; Sorgatz and Ammesdorfer [50] tackled the problem. Sachs and Chen [51] used a theoretical approach, via Liapunov, in studying the stability of nonlinear motions, but the method seems cumbersome.

Gaub and Rompe [52] used a vehicle simulation to investigate an important nonlinear area of lateral dynamics -- the effect of braking during cornering.

Other papers were concerned with the transient response of automobiles. A problem of great difficulty to automobile dynamics engineers. Zomotov [53] presented an optical method for measuring slip angle of the vehicle. Others [54] investigated the ubiquitous lane-change maneuver and demonstrated that before it can be considered a controllable test procedure, a number of difficult problems must be overcome. Lippmann and Oblizajek [55] used simple modeling techniques to study the effect of tire force dynamics on vehicle response and report differences in response.

Barter [56] reviewed the techniques used to analyze experimental vehicle handling data and concluded that steady-state behavior is reasonably well understood; transient behavior requires considerable further study even though progress is being made. Sorgatz [57] reviewed simulation of directional behavior of road vehicles and concluded that complex models are needed for wide applicability. The cost of a comprehensive simulation facility is thus high.

Trucks. The objective of a paper by Susemihl and Krauter [58] is to prevent jack-knifing in tractor semi-trailer trucks with a mechanism that senses drive axle behavior so that corrective braking action can be used. Shapley [59] investigated roll-over behavior of tractor semi-trailer combinations in an assessment of the importance of tire and suspension properties in overturning.

DISCUSSION

Overall, the primary feature with regard to ride quality studies is that data processing techniques are being used, not only in on-line (or quasi-on-line) data processing -- in which large volumes of experimental data are manipulated to yield desired data -- but also in design-oriented computer studies. On-line data processing relies largely on 'random process' analytic techniques; design-oriented studies require extensive mathematical modeling of the engineering processes involved.

In addition activity on the standards front has resulted in ISO 2631. It is to be hoped that with attainment of the bureaucratic objective the standards will be modified in the light of advancing knowledge.

Tire behavior -- especially transient behavior -- has dominated handling studies in recent years. The reason is that transient vehicle response is not yet very well understood. Most of the effort since 1975 has been devoted to the complex nature of tires, particularly with regard to frequency response. Transient response of vehicles is also the major theme of the car studies. A significant effort has been made in mathematical modeling of vehicle handling, but, thankfully, somewhat less emphasis has been placed on Runge Kutta-type time history solutions than was fashionable before 1975.

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Ride and Handling

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LITERATURE REVIEW

survey and analysis of the Shock and Vibration literature

The monthly Literature Review, a subjective critique and summary of the literature, consists of two to four review articles each month, 3,000 to 4,000 words in length. The purpose of this section is to present a "digest" of literature over a period of three years. Planned by the Technical Editor, this section provides the DIGEST reader with up-to-date insights into current technology in more than 150 topic areas. Review articles include technical information from articles, reports, and unpublished proceedings. Each article also contains a minor tutorial of the technical area under discussion, a survey and evaluation of the new literature, and recommendations. Review articles are written by experts in the shock and vibration field.

This issue of the DIGEST contains the second part of an annotated bibliography on linear elastic wave propagation. This article, written by R.A. Scott, reviews discretely nonhomogeneous media, continuous nonhomogeneous media, anisotropic media, and diffraction.

A review article on parametric vibration by R.A. Ibrahim is continued. It contains technology on sloshing liquids; beams, pipes, and rods; and plates and shells.

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LINEAR ELASTIC WAVE PROPAGATION. AN ANNOTATED BIBLIOGRAPHY: PART II

R.A. Scott*

Abstract - This survey of the literature on linear elastic wave propagation consists of two parts. Part I covers homogeneous isotropic media. Part II covers discretely nonhomogeneous media, continuous nonhomogeneous media, anisotropic media, and diffraction.

DISCRETELY NONHOMOGENEOUS MEDIA

This section covers the following: layered media and composite media.

Layered Media

For organizational purposes papers cited in this section have sometimes been classified as mechanics papers or seismology papers.

Harmonic wave propagation in joined semi-infinite media has been studied extensively. Bunney and Goodman [288], in an attempt to better understand circumferential waves, studied the interface motions between two perfectly bonded elastic media. Becker and Richardson [289] examined reflection and transmission coefficients for angles close to the Rayleigh critical angle. Comninou and Dundurs [290] assumed that one half-space was rigid and allowed separation.

Kaliski [291] examined interface waves with half-spaces connected by a thin layer. Murdoch [292] relaxed boundary conditions to allow for interfacial elasticity, inertia, and residual stress. He found that Stoneley waves almost always exist. The existence of Stoneley waves under conditions of lubricated contact was investigated by Murty [293], and the Stoneley period equation was explored by Pilant [294]. Schoenberg and Censor [295] considered interface conditions for moving media to be connected through a layer of viscous fluid. Staecker and Wong [296] studied frictionless contact as the thickness of a fluid layer vanished. Other harmonic wave propagation work has involved the vibration of a cylindrical shell immersed in a fluid overlying a solid half-space [297].

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Steady-state response to moving loads or transients has been considered. Cagniard's method was used for a subsonically expanding disk load at a fluid-solid interface [298]. A line source on a solid-solid interface was examined [299], as were reflections of spherical pulses from a fluid-solid interface [300]. Steady-state responses were applied, using Cagniard's method to various moving sources in a fluid-solid system [301-303]. Experimental results on the interaction of a cylindrical pulse with a fluid-solid interface were given [304]. An integral equation formulation for the interaction of plane waves with a fluid-solid interface has been presented [305], and it has been shown that an expanding crack on an interface can generate a conical wave [104].

Harmonic waves in various configurations with finite layers have also been treated in the mechanics literature. One-dimensional wave propagation through a layer on a half-space was studied [306], and equations for thin elastic plates lying on a thin elastic layer were developed [307]. A fluid layer bounded by two Timoshenko plates, one of which was driven by a point load was studied [308], and an approximate analysis using integral equations for a thin elastic layer on a half-space was published [309]. Torsional motions of a layer on a half-space were examined [310].

Krajcinovic [311] developed a theory for laminated beams and gave spectral data for the case of three layers. In similar work, addition spectra for five-layer beams were also given [312]. Asymptotic expansions were used to develop theories for two-layered plates and cylinders [313, 314], and an approximate theory was used to obtain dispersion relations for axisymmetric waves in layered cylindrical shells [315]. Integral equations were used to examine the SH-motions of a layer on a half-space [316]. Linear theory and a five-mode shell theory were used on the vibrations of two-layered spheres to obtain spectral data [317].

Torsional motions of two-layered cylindrical rods were analyzed [318] and transients for such geo-

metries given by a photoelasticity study of a layer on a half-space [319], the limiting case study of a rigid strip bonded to a half-space [320], and a study of two-layered plates that included the effects of rotatory inertia and transverse shear and used the saddle-point method for far-field results [321]. Scott [322, 323] used linear theory to obtain head-of-the-pulse approximations for a symmetric three-layered plate and a two-layered rod with imperfect interface bonding. Viano and Miklowitz [324] also used linear theory for head-of-the-pulse, as well as Rayleigh and Stoneley-wave approximations, for step-load excitation of symmetric three-layered plates. Watanabe [325] used Cagniard's method to study a moving load on a layer bonded to a half-space. Ziv [326] used characteristics to extend his earlier work on two-layered shells to the case of many layers.

Layered media have been a subject of intense seismological research, particularly since computer technology has made examinations of realistic earth models possible [327]. Much work has been done on harmonic waves (or in the transformed domain). Bache and Harkrider [328] studied source mechanisms. Hudson and Douglas [329] related strong minima in certain group-velocity curves to the resonance of vertically traveling P-waves. Jobert [330] presented results on Green's functions, and Kausel and Schwab [331] used the Biswas-Knopoff earth-flattening transformation to obtain the responses of spherical structures to point loads. Related studies have also been published [332-334].

Panza and Calcagnile [335-336] proposed using higher-mode amplitude spectra to distinguish structures with and without a low-velocity channel (LVC) and showed that the vertical and longitudinal component of the wave Lg can be identified with higher Rayleigh modes [337]. They also confirmed that an LVC is not necessary for the existence of the wave Lg. Panza, Schwab, and Knopoff [338-340] gave extensive numerical results on frequency spectra for various sources and showed that, for studies on short-period surface waves, only the crustal-wave portion of the spectrum need be considered even if only a slight LVC is present [341].

Radovich and De Bremaecker [342] examined the leaking modes of Love waves. A thorough interdisciplinary discussion of the use of such modes in asymptotic representations has been published [343]. Surface waves were examined using transversely isotropic models or numerical methods [344].

Results on body-wave leaking modes have been published [345]. The wave Sn, whose prominent feature is the abundance of short-period oscillations, has been interpreted [346]. In a mechanics-oriented study, the role of leaking modes on the vibrations of a submerged plate was examined [347, 348]. Other leaking mode studies have been done [349].

Transients have been studied using modal synthesis by Knopoff, Schwab, and Kausel [350], who interpreted Lg in terms of higher-mode Love wave propagation. SH-responses due to a dip-slip source were obtained [351].

Probably the most important recent development with regard to transients was the emergence of a generalized, or "exact," ray theory. It consists of Cagniard methods together with techniques of ray summing; the latter frequently involves only first reflections. The reflectivity method should also be noted. (See Richards' review [352] for a discussion.)

Work on the ray theory and the reflectivity method has been published. Multi-polar sources were studied [353]. A method was published for the near-field in which the source is represented as a superposition of homogeneous and nonhomogeneous plane waves propagating at discrete angles [354]. Limitations of the generalized ray theory were discussed [355] as were errors in the asymptotic ray theory [356-358]. Cisternas, Betarcourt, and Leiva [359] showed how complete ray expansions can be generated. Dainty and Dampney [360] compared the ray theory with the leaking mode theory.

Synthetic seismograms have also been studied [361-366]. Helmberger and Gilbert [367] developed a generalized ray theory for a layered sphere. An iterative approach to the calculation of reflection and transmission coefficients has been presented [368]. Müller wrote on the reflectivity method [369]. The possible inadequacy of plane-wave reflection and transmission coefficients, in view of the actual curved nature of wavefronts has been pointed out [370]. A method involving a progressing-wave formalism somewhat akin to Cagniard's method was developed [371]. Finite-difference work was done on

synthetic seismograms [372, 373], and a review article is in preparation [374].

Lateral nonhomogeneities are beginning to receive attention. Studies in addition to those already cited [224-287] include placement of leaking modes in an approximate scheme [375-377] and development of a KBM approximation for small lateral variations [378] as well as finite-element techniques [379, 380]. An approximate scheme for a material discontinuity in a layer involved replacing it with a homogeneous layer with sources [381-383]. Horizontal structures was allowed for because the source- and receiver-windowed ray cones sample different regions of the crustal structure [384]. Landers and Claerbout [385] presented a perturbation scheme, and Luh [386, 387] extended previous work on expansions of nonhomogeneities into spherical harmonics [388, 389]. Ray theory and the idea of additive interference were used to obtain spectral data [390]. Other work involving ray-tracing methods has also been reported [391-394].

Composite Media

This section supplements the recent reviews of Bert [395, 396], Gibson and Plunkett [397], and Ross and Sierakowski [398]. Many theories have been developed to describe laminated composites: a mixture theory [399]; low-frequency approximations for one-dimensional waves, arbitrary spatial variation being allowed [400]; microstructure theories [401-404]; observations on the boundary layer effect [405-407]; a theory involving differential-difference equations [408]; long wavelength approximations for propagation normal to the layering, using the Boltzmann constitutive law [409]; a very accurate and effective stiffness theory [410, 411]; debonding [412-416], and hierarchies of theories of interacting continua [417-420] and their application to plates [421]. Another accurate and effective stiffness theory [422] involved low-frequency approximations and "head-of-the-pulse" solutions for one dimension [423]. These were extended to three dimensions [424]. A relatively simple theory was also proposed [425].

A common test of the accuracy of a theory has been to compare disperison curves with those given by linear elasticity theory. (Other comparisons have involved moving loads [426]. Floquet (and SH-) waves were examined [427]. Variational principles were used [428, 430] and discussed [429]. Efficient numerical methods were developed [431, 432]. Exact-theory information for cases involving more than two laminates was published [433]. The Hellinger-Reissner variational principle was modified to provide spectral data [434-438]. Linear-theory spectra were given for propagation normal to the layering and the results compared with experiments [439]. Linear-theory spectra for SH-waves were also obtained [440].

Aboudi [441] used finite-differences and linear theory to study transients in a plate having laminations perpendicular to the surfaces. Balanis [442] examined one-dimensional waves using Fourier synthesis, and Sve and Herrmann [443] used the effective stiffness theory to investigate a supersonic moving load on a half-space. Sve and Okubo [444] compared experiments and results from finite-differences and the effective modulus theory.

Work on fiber-reinforced composites has been reported. A mixture theory was developed for the case in which fiber direction differs in alternate layers [445]. The theory was used to analyze moving body forces [445]. Mixture theories were also given for fibers in rectangular arrays [446, 447]. Predictions from a mixture theory have been compared with experiments [448]. Averaged equations were given for longitudinal waves propagating normal to randomly distributed fibers [449]. An average rigidity was obtained for a random distribution of fibers [450].

Hlaváček [451] developed an effective stiffness theory for a hexagonal layout of fibers. The effects of slight variations in fiber direction have also been studied [452, 453].

Spectral data have been given for a Ritz method used to study rectangular arrays of fibers [164, 434, 437, 454]. Applications include those of Choi and Bedford [455], who examined excitation by normal and shear surface tractions of a half-space -- the fibers being at an arbitrary angle -- and those of Eason [456], who studied waves emanating from a cylindrical cavity in an infinite medium with an effective modulus theory.

Other than the extensive literature on diffraction by a single inclusion, little work has been published on

particulate composites. Dilute suspensions of rigid spheroidal inclusions were studied [457]. A perturbation method for harmonic waves involving a three-dimensional array of periodic inclusions was developed [409, 458], as was a theory for a two-phase material in which one phase contains inclusions [459]. Experimental results and a ray tracing analysis for one inclusion were published [460].

Considerable work has been done on various structural configurations. Effective-modulus theories have been used for one or more of the components [461-474]. The references on anisotropic media are also relevant.

CONTINUOUSLY NONHOMOGENEOUS MEDIA

Work on infinite media includes ray methods that account for both anisotropy and nonhomogeneity [475-478]. An asymptotic analysis for turning points that is equivalent to the uniform Langer approximation was reported [355, 479]. A WKB-approximation for the forward propagation of one-dimensional waves and a higher order approximation for the reflection process were published [480], as were wavefront approximations [481, 482] and far-field responses obtained from a combination of high-frequency approximations and stationary phase [483].

Razavy [484] used a perturbation scheme in a study on an inverse problem for one-dimensional waves. Richards [485] developed a set of coupled wave equations, with reduced coupling for potentials, and showed that they decoupled as frequency became very large; Mukhina [486] also showed the latter, and Richards [487] developed saddle-point methods for rays near caustics. (Langer's uniform asymptotic approximation has also been used in studies of the interaction of waves at near-grazing angles with a discontinuity [370].

Studies on semi-infinite media include those of Awojobi [488], who presented low-frequency approximations for torsional motions with the density constant and the shear modulus increasing linearly with depth. He found that variations with depth were relatively unimportant [488, 489]. In other studies series solutions were used to obtain Rayleigh-wave data for a medium having exponential variations in density and shear modulus and a constant Poisson's ratio [490]. Solutions were given in the transformed domain for media with exponential variations [491]. Harmonic torsional motions were examined for media with special variations in vertical and horizontal properties [492]. Series solutions were used to study Rayleigh waves in media for which only Poisson's ratio varied [493]. Far-field responses to harmonic line and point loads were obtained with asymptotics and stationary phase [494]. Data on reflection and transmission coefficients and on Rayleigh and Stoneley waves were given for a liquid overlying a half-space [495]. The material parameters of the solid (Poisson) obeyed a power law.

Published work on plates, rods, spheres, and shells includes variations leading to Bessel, hypergeometric, and Whittaker functions [496, 497] and the use of Karal-Keller asymptotics, transforms, and wavefront expansions to study one-dimensional waves [498]. Vibrations of a Poisson solid were studied with power law variations in the parameters [499]. Matrix transformations were used for certain classes of density and Young's modulus variations to reduce one-dimensional propagation to a form associated with the wave equation [500].

A perturbation scheme was reported for bodies of arbitrary shape [501]. Series representations of the difference between two fundamental solutions, one example of which was a thin plate, were reported [502], as was a corresponding membrane problem for a thin plate with complicated boundary conditions [503]. Lin [504] used extended Hankel transforms to obtain the harmonic one-dimensional response of finite rods; the material parameters obeyed a power law.

Formal, torsional solutions were presented for exponential variations [505], as were spectral data for a rod (and Love waves) using perturbations about the homogeneous case [506]. WKB and high-frequency approximations were used to study one-dimensional propagation [507], and a perturbation scheme was given for harmonic periodicity [507]. General studies on one-dimensional waves, in which Fourier series were used in time, led to differential equations for the coefficients [508]. Radial vibrations for media with constant Poisson's ratio were examined with Hankel transforms [509]. Limited information for power-law variations has been published [510,

511].

Waves in various layered configurations have been studied. High-frequency approximations for surface waves were published [512], as were stationary-phase approximations for harmonic motions of media with exponential variation [513] and Love-wave data for media with exponential variation, including ray-tracing and constructive interference to obtain lateral nonhomogeneity [514]. Love waves, including some anisotropic effects, were also examined [515, 516] and the following included: the effect of an interface irregularity [517], power-law variations [518], exponential variations [519], and first-motion approximations for power-law variations using asymptotic solutions to differential equations [520].

ANISOTROPIC MEDIA

Infinite-media studies have been published. Beeves [521] established conditions to ensure continuous dependence on initial data. Characteristics were used to examine step and ramp radial-stress inputs on a cylindrical cavity in a transversely isotropic material -- a model of a fiber-reinforced composite [522]. It was shown that -- given three arbitrary coplanar directions -- energy velocities corresponding to the three waves that can propagate in each direction are connected via a relation independent of the elastic symmetry [523-525]. Wave surfaces in cubic media were examined [526], and data were given for wave surfaces in paratellurite [527].

The diffraction of SH-, P-, and SV-waves were studied with a finite crack located on a symmetric surface [528, 529]. Wave surfaces in media were investigated using four elastic constants [530]. Payton [531] showed that Green's function for a transversely isotropic solid could be cast into closed form, provided a certain relationship between the elastic constants was satisfied. He also developed results for the symmetry axis of transversely isotropic media for a time-dependent body force [532].

In addition to the work cited on SAW-devices have been other reports on the half-space. These include the development of efficient schemes for computing surface waves [533, 534], the use of Cagniard's method to analyze Lamb's problem for zinc [535], and an investigation of pure modes -- that is, modes for which the displacements are coplanar with the surface and wave normals [536]. These modes can have the same features as Rayleigh waves -- i.e., waves with exponential decay -- and uniqueness can be established by using positive definiteness of the strain-energy [536]. Establishment of uniqueness is important because uncertainty regarding surface waves remains.

Currie [537] rediscovered Stroh's result, which stated that unattenuated waves could exist in continuous sectors as opposed to discrete directions.

The effects of an axial force on the steady motion of an inflated tire rolling on an anisotropic solid were studied [538], as were vibrations of rectangular indentor on a transversely isotropic medium [539]. Reflection coefficients for hexagonal materials and quartz were analyzed [540, 541], as well as the effect on surface waves of changing rhombic symmetry to monoclinic symmetry [542]. Limited results were published for torsional motions of a cylindrically anisotropic medium [543]. Rayleigh waves (i.e., complex decay factors) were generalized for transversely isotropic media [544].

Theoretical and experimental studies were made on excitation of a transversely isotropic medium (Yule marble) by a normal surface load [545-547]. The experimental results were in excellent agreement with predictions from a finite-element analysis of the near-field and a Cagniard method for the far-field. Photoelastic experiments were developed [548]. The invertible properties of the matrix that arise in computing amplitude ratios were investigated [549].

The related geometry of joined half-spaces has also been considered. It was shown that Stoneley waves are not confined to discrete directions [550]. A critical angle was interpreted as one for which the energy flux vector -- as opposed to the wave vector -- first becomes parallel to the free surface [551]. The use of critical angles to measure elastic constants was a subject for cautionary remarks [552]. The critical points for determining the domain of existence of Stoneley waves were shown to be characterized either by the vanishing of the wave velocity or attenuation normal to the interface [553].

In addition to the work cited on composite media [395-474] is work on plates, rods, and shells. Finite elements were used to obtain frequency information for orthotropic rods of square cross section [554]. Results for hollow, orthotropic, circular rods, obtained with Frobenius theory and with linear elasticity theory, were compared [555]. Torsional and longitudinal wave dispersion curves were published for infinite, transversely isotropic cylinders [556]. The method of Frobenius was used to obtain spectral data for non-axisymmetric modes of infinite, orthotropic cylinders [557].

Ritz methods were used to obtain spectral data for rods of rectangular cross section [558, 559], and approximate equations were developed for quartz plates and the resulting spectra compared with those from linear elasticity theory [560]. Padovan and Lestingi [561] used an approximate theory to obtain spectral data for monoclinic circular plates that model fiber reinforcement. Randles [562] considered transient excitation of an infinite orthotropic plate and gave approximations for the motions near the tips of cusped wavefronts. The approximations were significantly larger than those for the isotropic case.

Fiber reinforcement was modeled with an effective modulus theory, and a Timoshenko theory was used to improve earlier results [564] on frequencies of orthotropic beams [563, 565]. Dispersion curves were published for axisymmetric modes of hollow orthotropic bars [566]. Solie and Auld [567] used Mindlin bounds to develop spectra for infinite cubic plates and studied relationships between plate waves and surface waves in directions for which pseudo-surface waves (i.e., waves that attenuate) propagate. They also gave general comments on the question of whether or not surface waves exist. Tso, Dong, and Nelson [568] remarked on spectra for layered, transversely isotropic plates. A perturbation scheme was developed to obtain dispersion curves for triclinic and orthotropic bars of rectangular cross section [569, 570].

Various layered configurations and other geometries have been studied. Spectra for a spherically isotropic hollow sphere were given [571]. It was shown that, for some orientations, even small anisotropic layers in the upper mantle can produce significant effects on surface motion [572]. Some information was reported on the vibration of two-layered, orthotropic spheres [573].

De [574] examined circumferential waves on a two-layered transversely isotropic cylinder and used perturbations to measure effects due to a surface corrugation. He also studied Love waves in a monoclinic layer sandwiched between orthotropic half-spaces [575]. Vibrations of simply supported, square, layered, transversely isotropic plates were investigated [576, 577]. Spectral data were published for curved, transversely isotropic Timoshenko beams [578], and limiting cases for spectra of a multi-layered configuration with a transversely isotropic layer were reported [579]. Transverse isotropy about the radius vector was assumed in studies of transients in a hollow sphere [580].

Schoenberg [581] extended the Haskell-Thompson matrix scheme for layered media to the most general anisotropic case, and Smith and Dahlen [582] used Rayleigh's method to analyze layered media with slight anisotropy. SH-waves were studied in a transversely isotropic nonhomogeneous (power-law variation) layer sandwiched between isotropic half-spaces [583]. Circumferential waves on anisotropic cylinders have been investigated [584, 585].

DIFFRACTION

Not surprisingly -- in view of widespread interest in crack propagation, nondestructive testing, seismology and soil-structure interaction -- elastic-wave diffraction has been actively studied in recent years, and various reviews have appeared. Included are two on acoustic excitation [586, 587], one on soil-structure interaction [588], and one on nondestructive testing [589]. Other work related to soil-structure interaction has also been published [590-599].

Work involving cracks and rigid strips, in addition to that already cited [2-59], has been published. A perturbation method was used to examine a thin barrier on a half-space [600]. Achenbach and Gautesen [601] used Keller's geometrical theory of diffraction to examine the interactions of long spherical waves with a semi-infinite crack. Fredholm integral equations of the second kind were developed for scattering of harmonic waves by a finite crack,

and numerical results for stress intensity factors and crack opening displacements were given [602].

Ghosh [603] used similarity solutions to study scattering of a plane wave by a semi-infinite rigid barrier lying on a fluid-solid interface and examined [604] scattering of Love waves by a vertical crack. Low-frequency approximations to Fredholm integral equations of the second kind were used to obtain far-field amplitudes and the scattering cross section for a rigid disk and a penny-shaped crack [605]. Wiener-Hopf methods were used to study scattering of Love waves by strips [606], and Erdogan and Gupta's method of solving singular integral equations was used to obtain stress-intensity factors for scattering of SH-waves by a vertical crack in a layer [607].

Numerical solutions were developed for three coupled integral equations for scattering by a protrusion at the mass-loaded boundary of a half-space [608-610]. Osborne [611] gave high-frequency approximations to Fredholm integral equations of the second kind for normal incidence of torsional waves on a penny-shaped crack. Sih and Loeber [612] corrected earlier work on torsional waves interacting with a penny-shaped crack. Coupled integral equations were solved by an iterative procedure to examine scattering of Rayleigh waves by a surface obstacle of finite length [613].

Studies on scattering of elastic waves by cavities, fluid, and elastic and rigid inclusions have been published. Matched asymptotic expansions were used to examine diffraction of harmonic SH-waves by rigid elliptic inclusion, an elliptic cavity, and a Griffith crack [614, 615]; P-waves were studied by a movable rigid spheroidal inclusion [614-616]. Fan and Chen [617] used Keller-Karal theory to examine scattering of P-waves by rigid convex objects with a corrugated surface. Boundary perturbation methods and high-frequency approximations were used to investigate scattering of plane P-waves by a movable rigid spheroidal inclusion [618].

Griffin and Miklowitz [619] examined the interaction of a step P-wave with a cylindrical elastic inclusion. They extended Friedlander's technique to interior regions to study wavefronts (and the effects of caustics) for various interior waves -- shear, diffracted, Stoneley, reflected, transitted (doubly refracted) exterior, and multiply-refracted. Gross [620] used an infinite series of Mathieu functions to analyze dynamic stress concentration for SH-scattering by an elliptical cavity. Boundary-perturbation methods were used to examine scattering by objects close to cylinders and spheres [621, 622]. A step P-wave incident on a spherical cavity was investigated [623], and eigenfunction expansions were used to obtain numerical results for hoop stresses at the cavity boundary. The scattering cross section in the Rayleigh limit (long wavelength) was presented for S-waves striking an elastic sphere [624]. Laplace and Fourier transforms were used to examine scattering of impulsive P-waves by a fluid circular cylinder [625].

Kennett [626] used perturbation methods and numerical integration via fast Fourier transforms to examine transients incident on a sand-lens-like object. Lawrence [627] used a low-frequency approximation to an integral equation to obtain the two leading terms in the scattering cross section for P-waves incident on rigid ellipsoids, spheres, and circular disks.

Long-wavelength approximations were given for a circular cylindrical cavity, fluid cylinder, elastic cylinder, and the scattering cross section for the cylindrical cavity [628, 629]. Other results on scattering cross sections have been presented, as well as differential scattering cross sections for plane and spherical pulses impinging on a spherical cavity [630]. Numerical solutions of integral equations were used to study cavities of arbitrary shape [631]. Eigenfunction expansions and a low-frequency approximation were used to obtain stress concentration factors and translational motions for a movable rigid spheroid under incident P-wave excitation [632].

Osaulenko [633] developed Fredholm integral equations of the second kind to study scattering by rigid disks. Eigenfunction expansion methods were again used to analyze scattering by a circular cylindrical fluid inclusion. Peaks and valleys in power spectra were also related to resonances of the fluid inclusion [634, 635]. Series of Mathieu functions were used to obtain stress concentration factors for P- and S-waves incident on elliptical cavities and rigid inclusions [636]. Sidman [637] commented on Iwashimizu's work [638] on scattering

by a movable rigid sphere.

Finite differences were used to study scattering of P-waves by a rigid cylinder [639]. Ting and Chou [640, 641] used ray methods to analyze reflections and transmission coefficients as well as the passage of plane and spherical waves through cylinders and spheroids; caustics were emphasized. Results showed that plastic yield can occur behind a wavefront before occurring at the wavefront. Experimental work on propagation through an inclusion was carried out [642].

Interactions of acoustic waves with elastic bodies have been studied. Cesaro means were used to overcome difficulties with convergence near finite discontinuities of modal solutions involving a spherical shell [643]. Interactions of transient sound pulses were studied with rigid spheres, rigid spheroids, and elastic spheres [644]. Spectral data were obtained with the aid of fast Fourier transforms. Similar work involving harmonic waves has also been done [645].

Frisk and Überall [646] analyzed harmonic cylindrical waves incident on a cylinder and showed the following: that, as the cylinder radius went to infinity, the creeping waves in the whispering gallery series combined to form transverse and longitudinal waves, that the cylindrical Rayleigh wave became the Rayleigh wave, and that the Franz and Stoneley (except in the case of glancing incidence) waves disappeared. Geers [647] combined shell theory that neglects transverse shear and rotatory inertia with modal synthesis to analyze a step-wave interacting with a circular cylindrical shell. He compared the results with a fixed rigid cylinder and a cavity.

Modal synthesis was used to obtain far-field pressures due to excitation of a spherical shell by a point harmonic source [648]. A combination of Timoshenko shell theory, the Watson transformation, and a high-frequency approximation was used to examine finite spherical pulses impinging on a cylindrical shell [649]. In another study of the excitation of a spherical shell by a point harmonic source, the pressure field in the vicinity of the spherical surface was determined by using the Watson transformation [650].

It was shown [651] that resonance of a normal mode depends upon equality between the phase velocity of a creeping wave and the modal vibration that corresponds to an integer number of wavelengths fitting over the circumference. Laplace transforms and wavefront expansions were used to investigate scattering of finite-duration pulses by hollow elastic spheres [652].

Structural elements and multiple scatterers have been studied by Berakha [653], who presented formal solutions in terms of infinite series for the interaction of harmonic shear waves and cylindrical cavities in a half-space. Bennett [654] extended Twersky's method in electromagnetic theory to three-dimensional elastodynamics and applied it to the case of diffraction of harmonic waves by a rigid cylinder near the surface of a half-space.

Thin-plate theory was used to examine the interaction of harmonic compressional waves and circular cavities in a plate [655]. A theory incorporating shear deformation and rotatory inertia was used to study scattering of flexural waves by a circular hole in a plate [656]. Formal, infinite series solutions were given for the interaction of harmonic SH-waves and a layered circular indentation on the surface of a half-space [657, 658]. Multiple series were used to calculate numerical results on diffraction by two spherical cavities [659].

Integral equations and a perturbation technique were combined to obtain long-wavelength approximations for SH-waves normally incident on two parallel, rigid strips [660]. Formal solutions were obtained for excitation of a layered, cylindrical shell by a point harmonic source [661]. Longitudinal waves in nonuniform bars were examined with Keller-Karal theory [662]. A small-wavelength approximation was used to obtain pressures near a shell of revolution; the results agreed well with those of experiments [663].

Works of a more general nature than those already cited, as well as studies of random media have been published. Results for moving media were developed [664]. Displacements specified over part of a boundary were treated, and the geometrical theory of diffraction was used to handle the resulting discontinuity [665]. Finite-element schemes were developed [666], and various methods used in diffraction problems, including the Watson transformation and rainbow expansions, were treated [667]. Chernov's perturbation method was used to analyze local, random

non-homogeneities, and the scattering cross section for a special correlation function was determined [668].

Datta [669] used matched asymptotic expansions in a consideration of scattering by a single spheroidal inclusion. He then used an averaging procedure to develop results for a random distribution of spheroidal inclusions. Gangi and Mohanty [670] extended Babinet's principle -- which relates fields set up by complementary screens -- to elastodynamics. Kennett [671, 672] gave approximate results that extended previous work [381-383] and combined integral equations and the Born approximation in an analysis of diffraction by lateral nonhomogeneities.

The conclusion that a simple relation exists between the scattered shear component due to an incident P-wave and the scattered compressional component due to an incident S-wave (polarized normal to the cylinder axis) was extended to elastic inclusions [673]. Integral equation methods were criticized, and Helmholtz and Kirchhoff expressions were developed for surface integrals in terms of natural quantities [674] -- namely, displacements and tractions. (A discussion of the problems associated with integral equations and interior problems has been published [675], as has a regularization procedure for exterior problems [676].)

An approximate method was developed that involved sequences of thin homogeneous layers (infinite and infinitely thin, in the limit) and ignored multiple reflections [677]. It was shown for elastic scatterers, that the extinction cross section -- which is the sum of scattering and absorption cross sections -- is directly related to the far-field displacement directly behind the obstacle [678]. General analytic and numerical results on harmonic scattering by cylinders were given [679-681]. Scattering-matrix theory was developed for elastodynamics [682, 683]. The theory has led to considerable understanding of underlying mathematical structure in other fields [343].

CONCLUSION

Relevant texts and review articles have been published on the fast Fourier transform [684-686], an important development in wave propagation that has been extended to Hankel transforms. The following have also been reviewed: self-similar solutions [688], thermal effects [689, 690], and electromagnetic effects [691, 692]. Other reviews have appeared [693-696].

Finally, work that was either unavailable or overlooked during the preparation of the body of the text include studies on cracks and earthquake sources [697-707]. Lateral nonhomogeneity of nonhomogeneous bodies has been treated with perturbations [708]. Finite elements were used to examine harmonic waves in a two-dimensional periodic structure [709], and Mindlin theory was used to obtain spectra for prismatic bars with compound cross sections [710]. Whitham's averaged Lagrangian was used to investigate lateral nonhomogeneity [711].

Numerical schemes have been proposed in connection with finite differences [712, 713]. Other work involves oscillations of a layer [714], the effect of interface separation on reflection and refraction of plane waves [715], transients in a spherical shell [716], and waves emanating from a cylindrical cavity in an anisotropic medium [717].

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PARAMETRIC VIBRATION
PART III. CURRENT PROBLEMS (1)

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Abstract - This survey of the theory of parametric vibration and its related current problems consists of five review articles. The titles are.

I. Mechanics of Linear Problems
II. Mechanics of Nonlinear Problems
III. Current Problems (1)
IV. Current Problems (2)
V. Stochastic Problems

Because it is inconvenient to refer to all published materials, the authors have tried to review the most important literature and to emphasize recent results. Parts IV and V contain lists of unreferenced literature.

Many engineering systems are subject to parametric vibrations and many aspects associated with them have been studied, including sources and suppression techniques. Current problems having to do with the free surface of liquids in closed containers; rods, beams, and pipes, plates; and shells are reviewed in this article.

FREE SURFACE OF LIQUIDS IN CLOSED CONTAINERS

Parametric resonance was first observed experimentally on the free surface of a fluid by Faraday in 1831 [1]. Other observations were reported by Lord Rayleigh [2-5] and Mathiessen [6, 7] late in the 19th century. Not until 1954 was the discrepancy between Faraday's and Rayleigh's observations on the one hand and Mathiessen's findings on the other explained in mathematical terms [8]. The analysis [8] led to a system of Mathieu equations in which the state of a free surface is dependent on the amplitude X and the frequency Ω of the vertical excitation. It was shown [8] that, if the plane free surface were unstable, the resulting motion could have a frequency equal to $\frac{1}{2}N\Omega$, where N is an integer. Experimental results [8] confirmed that damping prevents the unstable regions from extending to the frequency axis.

Bolotin [9] and Sorokin [10] found that introduction of a linear damping term to the Mathieu equation remarkably reduced the regions of instability. Brand and Nyborg [11] experimentally measured the critical excitation amplitude X_C, under which the free surface of the liquid would remain plane. The measured values of X_C were much greater than those predicted by theory, and it was assumed that the difference was due to a lack of well developed theories for determining the free surface damping coefficient of a liquid.

Woodward [12] suggested that sufficient damping occurs in most real fluids so that all unstable regions, with the exception of the first several, will be located above a straight line passing through the origin of the Ince chart. He concluded that only those modes in the lower frequency range must be considered.

Since the advent of aerospace vehicles, the problem of liquid parametric sloshing has received considerable attention. The free surface oscillations of liquid propellants inside rocket tanks exert forces and moments on the vehicle and can interact with the dynamics of the control system and/or the structural system. Interest in liquid parametric sloshing resulted in theoretical and experimental investigations [13-15]. A nonlinear analysis for the free surface response of a liquid, including the coupling of a number of sloshing modes, has been given for a rectangular tank [16] and for a circular tank [17]. The latter investigation [17] showed that symmetric liquid modes appear as prominently as anti-symmetric ones. Half-frequency subharmonic and harmonic liquid motions were observed, but the latter were less common.

Chu [18] used a perturbation theory developed by Moiseev [19] to investigate the subharmonic response of the free surface of a liquid in an arbitrary axisymmetric tank. Woodward and Bauer [20] considered an annular sector of a cross section of a tank partially filled with liquid. Stability considerations made the occurrence of harmonic and superharmonic responses very unlikely, and they concluded that a response at the frequency equal to $\frac{1}{2}N\Omega$ could be

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maintained if disturbances resulting from such factors as equipment imperfections were less than the order of $(X/a)^N$, where X is the amplitude of vertical excitation, and a is the tank radius.

The influence of tank geometry on the parametric response of the free surface of a liquid has been determined by Kana [14, 21], Lomen and Fontenot [22], and Woodward and Bauer [12, 20]. Because mathematical analysis of certain geometrical configurations was difficult, Kana [21] conducted experimental investigations on 90°-sectors of cylindrical and spherical tanks. The response of the liquid in both containers was essentially the same as that in a cylindrical tank, especially the half-frequency subharmonic response. The free surface modes of liquids in a spherical tank were dependent on liquid depth.

The effect of parametric excitation on the discharge of liquid propellant from the tanks of space vehicles has been studied experimentally [23]. The flow slowed greatly as the amplitude of the vertical acceleration level increased. On the other hand, this flow rate decreased more slowly as the frequency of excitation increased for a fixed acceleration amplitude.

Goldberg [24] considered that parametric resonance of a plane-parallel fluid layer might explain the occurrence of subharmonic and harmonic frequencies. He gave conditions for the parametric amplification of standing waves.

Experimental and analytical investigations were carried out on cross waves generated in a tank with a rigid wall opposite the wave maker [25, 26]. Cross waves are standing waves with crests at right angles to the wave maker. They generally have half the frequency of the wave maker and reach a steady state at some finite amplitude. Parametric instability in this case in interpreted in terms of the work done by the wave maker against transverse stresses associated with the cross waves.

Bown and Inman [27] observed half-frequency edge waves that grew slowly to a very large amplitude. Because the frequency of edge waves depends on the slope of the free surface, they can be excited parametrically by harmonic variation of this slope due to the increasing amplitude of the waves.

An analytical investigation was carried out to determine the stability of semi-infinite rotating flow contained between two flat surfaces normal to the axis of rotation [28]. The temporal behavior of a small amplitude axisymmetric perturbation to the basic flow was governed by a second order differential equation with periodic coefficients.

Gershuni and Zhukhovitskii [29] discovered a parametric resonance called convective instability in a fluid body subjected to a periodically varying temperature gradient. The stability of the equilibrium depended not only on the mean temperature gradient, as in Rayleigh's problem [4], but also on the amplitude and frequency modulation. Gershuni and Zhukhovitskii [30] also found that modulation of the vertical temperature gradient had the same influence as modulation of the angular velocity of rotation of the fluid as a rigid body.

Studies of the parametric response of the interface between two dielectric liquids under the action of an alternating electrostrictive force [31-33] have shown that, in order to maintain stability of the interface, the applied voltage must be sufficiently high to suppress surface tension effects but lower than a certain analytically determined critical value. Similar studies [34] were carried out to determine the stability of a liquid jet in a time-dependent electric field. The effects of the frequency and the strength of the electric field on jet stability were determined from a stability analysis of the Mathieu equation.

Instability of the free surface of a liquid resulting from internal resonance has been studied for standing waves [35]. The autoparametric coupling of liquid sloshing modes in an elastic structure supporting a liquid container has been studied [36, 37]. It was shown that with principal internal resonance ($\omega_2 = 2\omega_1$) the system had a complete steady-state response. With three-mode interaction, however, the system might not achieve a steady-state when the three modes have the frequency relation ($\omega_3 = \omega_1 + \omega_2$). Additional sloshing modes gave rise to the possibility that multiple internal resonance [38, 39] might occur. In such a case the interaction involves irregular bearing motions of the free surface of the liquid and the elastic support structure.

RODS, BEAMS, AND PIPES

Such elastic members as rods, beams, and columns are essential parts of many structural systems. They are usually under various types of loads, and parametric loading is a significant factor in causing dynamic instability and structural failure.

The earliest observations of parametric instability in a simple elastic element were those of Melde [40] in 1859. In 1924 Beliaev [41] analyzed the parametric instability of a column pinned at both ends and reduced the governing differential equations to a Hill-Mathieu equation. Beliaev's work has been extended [42-61], and such factors as nonlinear effects, geometrical imperfections, end conditions, damping of the material, and the nonstationary nature of the excitation have been incorporated.

It is believed that experimental investigations of the validity of theoretical results were first conducted by Utida and Sezawa [61] in 1940 and Bolotin [43] and Weingarten [62] in the 1960s. Bolotin pointed out that beats can occur at the same time as steady-state vibrations. Simultaneous occurrence of the two types of motion prompted Somerset and Evan-Iwanowski [63] to conduct further experiments in 1967 using more accurate equipment. They observed two types of stability-instability boundaries, one of which is due to small amplitude motion and the other to large amplitude instability. The latter is characterized by either beating motion or constant peak vibration. Beating motion was attributed to a nonlinear effect of the natural frequency of the column because it depends on the lateral amplitude.

The presence of more than one stability boundary for the same mode was confirmed experimentally by Handoo and Sundarajan [64]. Grypos [65] considered nonlinear elastic characteristics in a study of the stability of a hinged bar supported at both ends.

Digital and analog simulations have been used to determine the instability regions of cantilevered columns for Euler and Beck problems [66]. The smooth cosine form of the applied load was approximated by successive piecewise constant loads in the digital simulation. Beats with a maximum amplitude larger than the initial disturbance were noted in the vicinity of one side of the boundary of the instability regions. On the other hand, beats with an amplitude smaller than that of the initial disturbance occurred in the vicinity of the other boundary. Sano [67] obtained the first four instability regions of a rod connected by a spring.

Piatek [68] considered Beliaev's problem and included the effects of the cross-sectional variation of an elastic beam. Ahuja and Duffield [69] determined the onset of parametric instability and the steady-state response of a beam on an elastic foundation. The slope of a beam with a linearly variable cross section has a pronounced effect upon the boundaries of the principal instability region. The elastic foundation decreases the width of the instability regions and the amplitude of the parametric response.

The response and dynamic stability of beams to nonplanar motion -- referred to as ballooning or whirling -- when subjected to plane harmonic excitations has been examined [29, 70]. The transition from planar motion to nonplanar motion is due to the nonlinear characteristics of some beams of specified cross section.

Evenson and Evan-Iwanowski [72] found that the nonlinear inertia of an elastic column drags the initially stable column into a catastrophic unstable state. An independent study [73], however, showed that the effect of nonlinear inertia is to decrease the response of the column.

The finite element method has been used to study the dynamic stability of bars having various boundary conditions [74]. Thomas and Abbas [75] extended this work to account for the effect of shear deformation on the static buckling loads and obtained the dynamic stability of a Timoshenko beam. As the rotary inertia increased, the regions of dynamic instability shifted closer to each other and their width increased. These results agree with those of Hagedron and Koval [76], who showed that the instability regions shift to the left on the stability chart because the bending frequency of a Timoshenko beam is smaller than that obtained with the Bernoulli-Euler theory.

Bauld [77] established an analogy between the dynamic stability of a homogeneous Euler column with pinned ends and a composite column with similar end conditions. Francis [78] considered a simply

supported Bernoulli-Euler beam excited parametrically by an extreme temperature gradient such that the elastic modulus varied as an exponential function through the length of the beam by the action of severe temperature gradient.

Parametric resonance of the second kind, combination resonance, has often been observed [76, 79-85]. Beal [84] obtained the regions of parametric instability of a flexible missile represented as a free beam subjected to periodic varying end thrust. Instabilities of principal and combination resonances for the bending modes occurred when the beam was very stiff lengthwise.

Dugundji and Mukhopadhyay [85] examined the parametric instability of a thin plate-like cantilever beam. A low-frequency mode of the beam could be excited by a rather large forcing frequency. (Bending and torsional modes can be excited simultaneously when the sum of their natural frequencies equals the parametric excitation frequency.) Hagedron and Koval [76] found that three cases of combination resonance can occur in a Timoshenko beam: between two bending modes, between two shear modes, and between one shear mode and one bending mode.

The possibility of combination resonance in columns having different end conditions has been thoroughly investigated [86-88]. With clamped-clamped ends a combination resonance exists at $\Omega = \omega_1 + \omega_3$; $\Omega = \omega_1 + \omega_2$ and $\Omega = \omega_1 + \omega_3$ are possible for a beam with clamped-simply supported ends. It has been found that combination resonance does not occur with columns in which both sides are simply supported [87]. A summed combination resonance occurs for a clamped-clamped column and a clamped-simply supported column. Sum and difference combination resonances occur with a clamped-tangentially forced column. A combination of external and internal damping had a destabilizing effect when internal damping was predominant [87]. Burney and Jaeger [89] established a numerical scheme for determining the regions of dynamic stability of columns with various end conditions. The instability of principal and combination types of a thin walled angle section of a cantilevered beam has been determined [79].

The dynamic stability of beams when under an impulsive load of arbitrary spatial distribution has been examined [90, 91]. Nonlinear coupling creates an interaction between the pulsating transverse flexural motion and the rotation about the longitudinal axis and the vertical axis of symmetry. As a result, a cyclic interchange of energy takes place between the axial and torsional motions.

Tso [92, 93] indicated that the regions of instability are larger for the higher torsional modes of an elastic cantilever. Two regions of instability exist for each mode. One is approximately twice the natural frequency of the torsional mode, and the other is close to the frequency of axial resonance. Popelar [94] found a number of mistakes in Tso's work and modified the instability regions. His analysis indicated that the net effect of pretension or precompression is, respectively, to decrease or increase the effective slenderness ratio. Such an effect could be detrimental or beneficial, depending upon whether the corresponding point in the stability diagram moves into an unstable or stable region.

Ghobarah and Tso [95, 96] presented nonlinear analyses of the stability of thin walled I-section elastic beams; they considered the inherent weakness in torsional resistance. The coupling between the axial and torsional motions was due to the shortening effect [93, 96] caused by large rotation of the beam sections. Ghobarah and Tso [96] indicated that viscous damping strongly influences the amount of overshot -- i.e., transient growth behavior -- and the manner in which the steady-state amplitude is approached.

Ghobarah [97] investigated the nonlinear parametric response of a thin-walled beam of monosymmetric cross section during coupled flexural-torsional vibrations having predominantly torsional characteristics. The stability of a clamped-free homogeneous uniform straight rod subjected to parametric excitation by two masses rotating in opposite directions has been examined by Mettler [98]. Terms representing inertia effects of the centrifugal exciter were important in defining regions of instability corresponding to principal and combination resonances.

Il'in and Kolesnikov [83] studied the stability of a simply supported elastic homogeneous beam in which the principal resonance $\Omega - 2\omega_1$ was almost equal to the combination resonance $\Omega = \omega_2 - \omega_1$. The

coupling between the principal and combination resonance decreased as the difference between $2\omega_1$ and $(\omega_2 - \omega_1)$ increased.

Such imperfections as initial curvature and load eccentricity act as sources of forced excitation; the resulting equation of motion becomes a nonhomogeneous Mathieu equation. The steady-state response of an initially curved column has been determined [43, 99-105]. McIvor [101] studied the nonlinear behavior of a column subjected to axial vibration by a pulsating axial force. Small imperfections can excite flexural modes as the excitation interacts with the curvature.

Stevens [106] considered a viscoelastic column and indicated that imperfections gave rise to lateral vibrations at all load amplitudes and frequencies. Anderson and Moody [107] determined the maximum transient lateral response of an initially curved beam. The steady-state amplitude was less than the transient maximum amplitude and affected the resulting stresses.

McIvor and Bernard [108] investigated the dynamic response of a simply supported column subjected for a finite period of time to axial loads. Axial inertia permits parametric resonance to take place at transverse modes as a result of the transient axial motion that occurs after the load is removed. With loads applied for a short period, the parametric resonance caused by transient axial motion can be significant even during dissipation. As the load is applied for longer intervals, parametric effects begin to dominate the response.

Movsisyan [109] determined the parametric instability of elastic pin-pin columns subjected to rapidly changing load conditions due to high velocities. The behavior of a beam in response to periodic impulsive axial forces has been investigated by Krajcinovic and Hermann [110] and Finizio [111, 112]. The instability regions of a column subjected to a rectangular periodic load was larger than that obtained for a sinusoidal periodic load [113].

Parametric excitation sources include oscillating magnetic fields [114, 115] and unsteady axial fluid flow with periodically varying velocity [116-118]. The effects of such excitations are similar to those obtained by applying dynamic loads.

The material properties of a system affect parametric response [106, 119-125]. Kovalenko [119] studied a column of constant stiffness and internal damping that was linearly proportional to the strain rate. Stevens [121] assumed various models of a viscoelastic column. With the three-parameter model -- Maxwell element and Voigt element in series with a spring -- the instability regions broaden and shift toward lower values of the exciting frequency as the viscoelasticity of the material increases.

Pipes conveying fluid with periodic flow velocities comprise a special class of elastic members in that a follower, or nonconservative, load can physically be realized. The first attempt to detect dynamic instability in pipes was by Natanzon [126]. Kondrashov [127] found that the amplitude of oscillations of an elastic pipe fixed at both ends is dependent on the ratio of the frequency of the fluid pressure fluctuations and the frequency of free oscillation of the pipe.

Chen [128] examined the stability of a simply-supported pipe conveying fluid with a flow velocity $U - U_0 (1 + \mu \cos (\Omega t))$, where U_0 is the mean flow velocity. Both principal and combination parametric instability were possible. The same problem was re-examined by Ginsberg [129], who showed that the nonconservative aspects of the forces merely modify the extent of the instability regions and do not cause any new phenomena.

Comprehensive studies of pipe line instability have been reported recently [130, 131]. The instability regions for clamped-clamped and pinned-pinned pipes increased with flow velocity. A more complex behavior occurred with cantilevered pipes: combination resonance was less important than the principal resonance except for flow velocities close to the critical resonance -- the point at which the stability of the system decreases in steady flow. Instabilities for pipes with clamped end conditions are associated with the sum of the eigenfrequencies. Instabilities of cantilevered pipes are associated with the difference relation.

Bohn and Hermann [132] considered two straight rigid pipe segments suspended in the manner of a double pendulum. The presence of small flow oscillations set up a destabilizing effect with regard to the principal and combination resonances.

PLATES

The early work pertaining to parametric instability of flat plates has been summarized [43, 46, 133 - 137]. Ambartsumyan and Gnuni [138] and Ligamov [139] determined the parametric instability and the steady-state of a nonlinearly elastic three-layered plate. Various cases in which anisotropic plates were subjected to periodic compression forces in principal directions or to a variable temperature field have been reported [138, 140-142]. Temperature changes were associated with substantial changes in the modulus of elasticity of the material over short time intervals, resulting in increased values for critical frequencies and smaller regions of principal parametric instability [142].

Johnson and Bauld [143] showed that the dynamic stability of both homogeneous and nonhomogeneous rectangular sandwich plates with hinged edges is governed by the same Mathieu equation; only the structure of the parameters differs. A similar analysis was developed for orthotropic plates [144].

Jagadish [145] examined the dynamic stability of a square plate having two modes of the same frequency. Instability can occur when the excitation frequency approaches twice the common frequency of the two modes; i.e. $\Omega = 2\omega_i = 2\omega_j$. The parameters that cause any mode shape to become dynamically unstable have been determined [146]. The size of the instability regions depended upon the degree of similarity of the mode shapes for free vibration and upon the static buckling.

The effects of body rotation about two or more axes have been studied [147]. For plates mounted parallel to the spin axis of a gyroscope, motion is governed by a set of Mathieu equations in which spin and precession are the two parameters of Ince chart. The maximal transient response of a plate subjected to both an in-plane and a lateral pulse was determined in a study directed at assessing the effects of sonic booms on structural elements [148]. With the exception of very flexible plates, the highest stress occurred during the interaction of the lateral and in-plane pulses. The length of time between excitations affected stress levels -- longer intervals increased stresses.

Experimental investigations on the parametric instability of plates have been conducted [149-151]. Dixon and Wright [149] considered plates having either clamped or free edges and subjected to periodic in-plane direct or shear loads. Such new phenomena as the transition attendant to the parametric vibration of a simply supported rectangular plate were observed by Somerset [151, 152]. The transition mechanisms of jump within the zone and dropout from the zone altered the size of the principal instability zone and might cause the region to split in two.

The effects of nonlinearities on stability-instability boundaries and the response of plates have been considered [43, 63, 153-155]. The onset of principal zones of instability are found to be significantly overlapped for a stiffened rectangular plate [156-159]. Duffield and Willems [160] investigated the onset of parametric instability in a stiffened plate in which the stiffeners were treated as discrete elements. Merritt and Willems [161] imposed certain boundary conditions on the shape of the plate. The size of the skew angle and the degree of stiffening were of critical importance in defining the principal region of the first spatial mode. Grundmann [162] examined the stability of a curved panel loaded by periodically variable axial pressure forces.

SHELLS

The dynamic instability of cylindrical shells was first considered by Markov [163] in 1949. Similar studies involving material properties and other factors have been carried out by a number of investigators [43, 164-170]. Gnuni [171] studied the parametric instability of a shallow thin elastic rectangular shell consisting of orthotropic layers rigidly joined to each other. Yao [172, 173] presented linear and nonlinear analyses of the behavior of a parametrically excited shell after it postbuckled.

The Liapunov direct method was used to define the stability of a cylindrical shell under radial pressure [174]. The application of an impulsive load to a thin cylindrical shell produced elastic destabilizing forces of various magnitudes [175, 176]. The influence of end conditions upon the principal instability region has been examined experimentally [177]. The important instability boundaries of a stringer-stiffened cylindrical shell were found to lie

between the instability boundaries for stringers and those for an unstiffened shell alone [178].

The stationary and nonstationary responses for a number of cylindrical shells under principal and additive combination resonances have been investigated [179-182]. Koval [183] found that the instability region of the combination resonance is narrower than that of the principal resonance. Analyses clarified the dynamic instability of cylindrical shells subjected to both static and periodic shearing forces uniformly applied along the edges [184]. One remarkable result was that, under purely periodic torque, the instability regions of combination resonance for two axial modes were parametrically excited; as the static shearing force increased, however, the principal instability regions became most significant.

Hsu [185] remarked on the parametric instability of cylindrical shells. He stated that parametric excitation could play a significant role in the dynamic behavior of shells, sometimes directly -- as in the case of external parametric excitation -- and sometimes indirectly, as in the case of autoparametric coupling.

Goodier and McIvor [186] presented numerical solutions to the nonlinear differential equations that couple the breathing mode and one flexural mode. The breathing mode transfers energy to the flexural mode over a large number of periods; the transfer then reverses, and energy returns to the breathing mode. Finally, the process again reverses, and energy passes once more to the flexural mode. This autoparametric instability has been confirmed by a number of studies [187-189]. McIvor and Lovell [188] showed that the unstable response is characterized by cyclic energy exchange in the flexural modes. The possibility that such a response will occur is increased by lengthening the shell and reducing its thickness. It has been indicated [187, 188] that flexural modes of high order (several nodes in the circumference) can be strongly excited when their frequency is equal to one-half the breathing mode; i.e., when internal resonance occurs. Hobka [189] obtained similar results by applying the quadratic form of Newton's method. Kalnins [190] studied the nonlinear coupling effects on the stability of a shroud for cooling pipes of a nuclear reactor.

These shell studies do not represent the real situation, however, because most cylindrical shells are used as liquid containers for liquid propellants and water [14, 15, 21, 191-195]. Bagdasaryan and Gnuni [196] considered a shell filled with a liquid, in a potential motion field; the depth of the liquid was subject to a prescribed variation.

A series of analytical and experimental investigations on liquid-shell systems subjected to parametric excitation [14, 15, 21, 193-195, 197] showed that the shell first responds in linear axisymmetric vibrational modes. Then -- within the excitation range of certain parameters -- nonsymmetric perturbations superimposed on the initial state become unstable [15]. As a result, the shell response includes a dominant nonsymmetric half-subharmonic component of displacement. The nonsymmetric breathing responses, which are similar to those excited by lateral excitation, also occur during longitudinal forced vibration [193]. The influence of various factors -- axial preload, pressure, partial liquid depth, and a finite top impedance value -- on the parametric instability of a model of a vehicle propellant tank was investigated [195].

The influence of the flexibility of the tank bottom on the parametric response of the free surface of the liquid has been studied [198, 199]. Chu and Kana [197] showed that the interaction of the free surface of a liquid with a vibrating elastic shell consists of regular and irregular beats in the unstable domain of the shell response. The structure-liquid coupling undergoes simultaneous low-frequency amplitude modulation of the high frequency shell response and the excitation of the liquid surface in an axisymmetric sloshing mode.

Kornecki [200] presented analytical investigations on a simply supported conical shell and obtained approximate solutions for the principal instability region. Tani [201] extended Korneck's work for truncated conical shell and found that the regions of combination resonance are much narrower than those of the principal instability. The instability regions move toward the lower frequencies due to the static axial compressive forces. He considered the effect of bending deformations before instability occurred [202] and found that the width of the principal instability regions increased to about twice the natural frequencies of asymmetric vibration. On the other hand, this effect could decrease the instability

regions that lie far from frequencies of axisymmetric resonance. Evenson [203, 204] considered shallow spherical shells and found that the jump phenomenon associated with soft nonlinear systems predominates in the shell response.

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BOOK REVIEWS

DYNAMIC PLASTICITY OF METALS

J.D. Campbell
Springer-Verlag, 1972

Dr. Campbell's monograph is derived from a series of lectures given in 1970 at the International Centre for Mechanical Sciences, Udine, Italy. A number of significant developments in both experimental and theoretical aspects of the dynamic inelastic deformation of metals since World War II are presented in a unified and concise way. A unique feature of the monograph is that experimental data are used to amplify the treatment of theoretical topics. In addition, the substantial bibliography that supplements the main text should be especially useful for the researcher interested in pursuing particular work.

The monograph is organized into four chapters. Chapter 1 describes both the phenomenological and dislocation theories of plastic deformation. Fundamental concepts and the corresponding constitutive models developed for both rate independent and rate dependent plastic flow are given. The range of experimental data presented makes evident the complex behavior of real materials even when so-called simple tests are used. Particularly interesting features of the first chapter are the various dislocation-based theories and the way in which certain assumptions about the dependent variables in these theories are linked to macroscopic aspects of time-dependent flow.

Chapter 2 is devoted to wave propagation, with special emphasis on longitudinal waves in slender rods and shear waves in a cylinder or disc. The method of characteristics is described in these applications. Parallel descriptions of rate independent and rate dependent constitutive models effectively demonstrate the differences in the resulting solutions. The inclusion of incremental waves and shock waves (i.e., of uniaxial strain) emphasizes the need for considering rate dependent response in describing certain aspects of wave propagation in metals.

Chapter 3 discusses experimental methods and results. Tests at medium and high strain rates, as well as a great deal of detailed information about the behavior of materials under uniaxial and biaxial stress loading are described. Topics include delayed yielding in steel, the effect of prestraining in polycrystalline aluminum, and strain rate history effects in niobium and molybdenum. The experimental technique considered in detail is the split Hopkinson bar, first developed by H. Kolsky in 1948 and used in recent years by Dr. Campbell and other workers. Data for material behavior at strain rates up to $\sim 10^4\ s^{-1}$ are included in this chapter.

The final chapter is devoted to several applications of dynamic plasticity. Such industrial applications as metal forming and machining are discussed. The effect of material response at high strain rates on the efficiency of these operations is shown. The behavior of structural elements under impact loading is also discussed along with some comments on crack propagation and the influence of the crack tip stress field on failure.

In summary, this monograph is a useful addition to the literature in the still relatively specialized field of dynamic plasticity. It is intended for researchers with some interest in, as well as knowledge of, the subject. One criticism of this work might be warranted -- it is perhaps <u>too</u> concise; that is, the treatment of some topics is too brief. It is therefore likely that the reader who is unfamiliar with the subject will not be satisfied unless he does additional research, but, as noted earlier, the ample references given should simplify this research in many cases.

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INTRODUCTION TO BOND GRAPHS AND THEIR APPLICATIONS

J.U. Thoma
Pergamon Press, 1975

This compact paperback book is the English language version of a book originally published in German by one of the original bond graph enthusiasts and contributors. Dr. Thoma provides an introduction to the modeling of all types of physical engineering systems using bond graphs, as well as a number of thoughts on the philosophy of mathematical modeling in general.

Because the book was written as a monograph rather than a textbook, there are no problem sets, and, although many components are discussed in some detail, only a few complete systems are analyzed. Although bond graphs can be used to generate state equations either by hand or through ENPORT programs, the author does no more than describe these processes, preferring to generate block diagrams from bond graphs in his examples.

One peculiarity is that the author chose to use his own notation for the three-port junctions. He uses p and s instead of the Paynter notation of 0 and 1 that has been used by all others in the field. His idea was to make it easier to remember the meaning of the three-port junctions for parallel and series connections in electrical and hydraulic systems. If the standard bond graph analogy is used, however, mechanical series and parallel connections do not correctly correspond to the author's p and s notation. It would seem better to retain the 0 and 1 notation normally used.

Although the reader of this book will probably not become a competent bond graph modeler, he will have had a good introduction to the aims and scope of bond graph techniques. Those whose interest is awakened by this book will find available a wide literature in many application areas.

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SHORT COURSES

APRIL

THE FOURTH ANNUAL RELIABILITY TESTING INSTITUTE

Dates: April 3 - 7, 1978
Place: Tucson, Arizona
Objective: This course is designed to provide Reliability Engineers, Product Assurance Engineers and Managers and all other engineers and teachers with a working knowledge of analyzing component, equipment, and system performance and failure data to determine the distributions of their times to failure, failure rates, and reliabilities; small sample size, short duration, low cost tests, and methods of analyzing their results; Bayesian testing; suspended items testing; sequential testing; and others.

Contact: Dr. Dimitri Kececioglu, Institute Director Aerospace and Mech. Engrg. Dept., The University of Arizona, Bldg. 16, Tucson, AZ 85721 - (602) 884-2495, 884-3901, 884-3054, 884-1755.

SURVIVABILITY, TESTING, MEASUREMENT, ANALYSIS, and CALIBRATION

Dates: April 3 - 7, 1978
Place: Wright State Univ., Dayton, OH
Objective: Increasing an equipment's ability to survive in the dynamic environments of vibration and shock will be the main subject of this course. This course will concentrate upon techniques and equipments, rather than upon mathematics and theory.

Contact: Wayne Tustin, Tustin Institute of Technology, 22 East Los Olivos, Santa Barbara, CA 93105 - (805) 963-1124.

SYSTEMS ENGINEERING

Dates: April 24 - 28, 1978
Place: UCLA
Objective: The course is offered to provide scientists technical staff and engineering managers a basis for planning, managing and performing systems engineering by presenting an integrated overview of the discipline and a summary of current theory and practice in emerging problem areas. The course analyzes decision making and the life cycle of an engineered system in order to develop a general approach for specifying the information outputs of systems engineering and identifying component activities, methodologies, techniques, and tools. The course provides a framework for thinking about and dealing with systems problems in any area of application.

Contact: Continuing Education in Engineering and Mathematics, UCLA Extension, P. O. Box 24902, Los Angeles, CA 90024 - (213) 825-1047.

CORRELATION AND COHERENCE ANALYSIS FOR ACOUSTICS AND VIBRATION PROBLEMS

Dates: April 24 - 28, 1978/Aug. 28 - Sept. 1
Place: UCLA
Objective: The course covers the latest practical techniques of correlation and coherence analysis for solving acoustics and vibration problems in physical systems. Procedures currently being applied to data collected from single, multiple and distributed input/output systems are explained to classify data and systems, measure propagation times, identify source contributions, evaluate and monitor system properties, predict output responses and noise conditions, determine nonlinear and nonstationary effects, and conduct dynamics test programs.

Contact: Continuing Education in Engineering and Mathematics, UCLA Extension, P. O. Box 24902, Los Angeles, CA 90024 - (213) 825-1047.

ANTICIPATING FAILURES OF ROTATING MACHINERY WITH VIBRATION ANALYSIS

Places and Dates:

Atlanta	April 18 - 20, 1978
Rochester	May 2 - 4
Schenectady	May 9 - 11
Cleveland	May 23 - 25
Chicago	May 30 - June 1
Houston	June 13 - 15

Objective: This seminar is a basic course in the analysis of rotating machinery vibration. Emphasis will be on why certain machine abnormalities produce specific vibration signatures. Topics to be covered in the seminar are: the distinctions between different types of transducers and vibration monitoring equipment, causes of common machine vibratory phenomena, diagnosing machine failure modes by signature analysis, and suggestions for possible corrective action.

Contact: John Sramek, Nicolet Scientific Corp., 245 Livingston St., Northvale, NJ 07647 - (201) 767-7100, ext. 505.

MAY

PRINCIPLES AND APPLICATIONS OF NOISE CONTROL

Dates: May 4 - 6, 1978
Place: San Francisco, CA
Objective: This course, which preceeds INTER-NOISE 78, will cover fundamentals of acoustics and noise control; in-plant noise control; design of facilitites for noise control, noise measurements and data reduction, and acoustical standards used in noise measurements.

Contact: INTER-NOISE 78 Conference Secretariat, P. O. Box 3469, Arlington Branch, Poughkeepsie, NY 12603 - (914) 462-6719.

OCEANOGRAPHIC INSTRUMENTATION

Dates: May 23 - 25, 1978
Place: University of Houston
Objective: The course will include a brief non-mathematical review of theory and the need for static and dynamic measurements. Selection of pickups will follow, together with considerations for the ocean environment. Participants will learn about readout instruments and transducers and will read both static and dynamic strain, displacement, velocity, acceleration and force. Electrical signals will be evaluated on a classroom digital signal analyzer, giving immediate classroom display of dynamic physical conditions in engineering terms.

Contact: Tustin Institute of Technology, Inc., 22 E. Los Olivos St., Santa Barbara, CA 93105 - (805) 963-1124.

SEPTEMBER

7th ADVANCED NOISE AND VIBRATION COURSE

Dates: September 11 - 15, 1978
Place: Institute of Sound and Vibration Research, University of Southampton, England
Objective: The course is aimed at researchers and development engineers in industry and research establishments, and people in other spheres who are associated with noise and vibration problems. The course, which is designed to refresh and cover the latest theories and techniques, initially deals with fundamentals and common ground and then offers a choice of specialist topics. The course comprises over thirty lectures including the basic subjects of acoustics, random processes, vibration theory, subjective response and aerodynamic noise which form the central core of the course. In addition, several specialist applied topics are offered, including aircraft noise, road traffic noise, industrial machinery noise, diesel engine noise, process plant noise and environmental noise and planning.

Contact: Dr. J. G. Walker or Mrs. O. G. Hyde, Institute of Sound and Vibration Research, The University, Southampton, SO9 5NH, England.

NEWS BRIEFS

news on current and Future Shock and Vibration activities and events

NOISE CONTROL ENGINEERING BEGINS SIXTH YEAR OF PUBLICATION

NOISE CONTROL ENGINEERING, the only refeeed technical publication in the United States devoted exclusively to noise control, begins its sixth year of publication in 1978. NCE is published bimonthly in cooperation with the Acoustical Society of America. In-depth articles appearing in NCE cover topics such as techniques for machinery noise control, community noise, aircraft noise, standards and measurements and engineering criteria for noise control. NCE was first published in 1973, and in October of that year Malcolm J. Crocker, Professor of Mechanical Engineering at Purdue University, was named Editor. Since that time, Dr. Crocker has made NCE a leading technical journal with a world-wide circulation.

NOISE CONTROL ENGINEERING is published by the Institute of Noise Control Engineering (INCE), a non-profit organization for professionals in the field. One of the purposes of the Institute is to advance the technology of noise control with emphasis on engineering solutions to environmental noise problems. The publication is available to libraries and to individual subscribers who may become Associates of the Institute.

Further information on NCE and other INCE publications may be obtained from the Institute of Noise Control Engineering, P. O. Box 3206, Arlington Branch, Poughkeepsie, NY 12603.

INTER-NOISE 78 TO DISCUSS EUROPEAN PROGRESS IN NOISE CONTROL

Two special sessions on European progress in noise control will be featured at INTER-NOISE 78, the seventh International Conference on Noise Control Engineering to be held at the Jack Tar Hotel, San Francisco, California, May 8 - 10, 1978. During the fall of 1977, Swedish industry initiated a campaign to reduce significantly the noise levels in working environments. A detailed description of this campaign will be given in a special session to focus on Sweden's new approach to noise control in industry.

Another special session at INTER-NOISE 78 will focus on European noise regulations. The Environmental Action Program (covering the period 1977-81) of the European Community (Common Market) calls for the development of an anti-noise plan to control noise at its source and to take account of the environment in which the source operates. Papers to be presented at INTER-NOISE 78 from Austria, Denmark, France, Germany, and the Netherlands will focus on activities within these countries to control noise, primarily at its source. Particular emphasis will be placed on the use of sound power levels to classify and regulate the noise emitted by industrial noise sources as well as by household appliances. In the last decade, considerable progress has been made in Europe on classifying noise emissions in terms of the sound power levels of the sources and in controlling these emissions at the source. The European specialists who will be describing their programs will present to the INTER-NOISE 78 audience the latest advances from Europe in regulating and controlling noise at its source.

Information on INTER-NOISE 78 may be obtained from the Conference Secretariat at P. O. Box 3469, Arlington Branch, Poughkeepsie, NY 12603 - (914) 462-6719.

ABSTRACT CATEGORIES

ANALYSIS AND DESIGN

- Analogs and Analog Computation
- Analytical Methods
- Dynamic Programming
- Impedance Methods
- Integral Transforms
- Nonlinear Analysis
- Numerical Analysis
- Optimization Techniques
- Perturbation Methods
- Stability Analysis
- Statistical Methods
- Variational Methods
- Finite Element Modeling
- Modeling
- Digital Simulation
- Parameter Identification
- Design Information
- Design Techniques
- Criteria, Standards, and Specifications
- Surveys and Bibliographies
- Tutorial
- Modal Analysis and Synthesis

COMPUTER PROGRAMS

- General
- Natural Frequency
- Random Response
- Stability
- Steady State Response
- Transient Response

ENVIRONMENTS

- Acoustic
- Periodic
- Random
- Seismic
- Shock
- General Weapon
- Transportation

PHENOMENOLOGY

- Composite
- Damping
- Elastic
- Fatigue
- Fluid
- Inelastic
- Soil
- Thermoelastic
- Viscoelastic

EXPERIMENTATION

- Balancing
- Data Reduction
- Diagnostics
- Equipment
- Experiment Design
- Facilities
- Instrumentation
- Procedures
- Scaling and Modeling
- Simulators
- Specifications
- Techniques
- Holography

COMPONENTS

- Absorbers
- *Shafts*
- Beams, Strings, Rods, Bars
- Bearings
- Blades
- Columns
- Controls
- Cylinders
- Ducts
- Frames, Arches
- Gears
- Isolators
- Linkages
- Mechanical
- Membranes, Films, and Webs
- Panels
- Pipes and Tubes
- Plates and Shells
- Rings
- Springs
- Structural
- Tires

SYSTEMS

- Absorber
- Acoustic Isolation
- Noise Reduction
- Active Isolation
- Aircraft
- Artillery
- Bioengineering
- Bridges
- Building
- Cabinets
- Construction
- Electrical
- Foundations and Earth
- Helicopters
- Human
- Isolation
- Material Handling
- Mechanical
- Metal Working and Forming
- Off-Road Vehicles
- Optical
- Package
- Pressure Vessels
- Pumps, Turbines, Fans, Compressors
- Rail
- Reactors
- Reciprocating Machine
- Road
- Rotors
- Satellite
- Self-Excited
- Ship
- Spacecraft
- Structural
- Transmissions
- Turbomachinery
- Useful Application

ABSTRACTS FROM THE CURRENT LITERATURE

Copies of articles abstracted in the DIGEST are not available from the SVIC or the Vibration Institute (except those generated by either organization). Inquiries should be directed to library resources. Government reports can be obtained from the National Technical Information Service, Springfield, VA 22151, by citing the AD-, PB-, or N- number. Doctoral dissertations are available from University Microfilms (UM), 313 N. Fir St., Ann Arbor, MI; U.S. Patents from the Commissioner of Patents, Washington, D.C. 20231. Addresses following the authors' names in the citation refer only to the first author. The list of periodicals scanned by this journal is printed in issues 1, 6, and 12.

ABSTRACT CONTENTS

ANALYSIS AND DESIGN

NUMERICAL ANALYSIS

78-377
Numerical Solution of the Unsteady Transonic Small-Disturbance Equations
M.M. Hafez, M.H. Rizk, and E.M. Murman
Flow Research Inc., Kent, WA, In: AGARD Unsteady Airloads in Separated and Transonic Flow, 13 pp (Apr 1977)
N77-31091

Key Words: Flutter, Numerical analysis

Problems that occur in the small unsteady harmonic perturbation approach of calculating transonic flutter problems are examined. Numerical instability that occurs in the relaxation procedure for solving the reduced potential equation is studied.

MODELING

78-378
'Strange' Phenomena in Dynamical Systems and Their Physical Implications
P. Holmes
Inst. of Sound and Vib. Research, Univ. of Southampton, Southampton SO9 5NH, UK, Appl. Math. Modeling, 1 (7), pp 362-366 (Dec 1977) 3 figs, 33 refs

Key Words: Dynamic systems, Mathematical models

Some recent developments in dynamical systems theory are outlined and their physical implications are discussed. In particular the concept of strange attractors: motions which arise as solutions of deterministic dynamical systems is introduced. They have extremely complicated and random structures.

DESIGN TECHNIQUES

(See No. 420)

SURVEYS AND BIBLIOGRAPHIES

(See No. 478)

MODAL ANALYSIS AND SYNTHESIS

78-379
Modal Analysis: Trouble-Shooting to Product Design
R.H. Russell and J.C. Deel
Zonic Tech. Laboratories, Inc., Cincinnati, OH, S/V, Sound Vib., 11 (11), pp 22-38 (Nov 1977) 26 figs, 3 refs

Key Words: Modal analysis, Diagnostic techniques

This article describes the modal analysis procedures used in problem solving on existing machinery, developing data bases for new designs and coupling experimental and analytical procedures to an integrated design approach.

78-380
Impulse Technique for Structural Frequency Response Testing
W.G. Halvorsen and D.L. Brown
Anatrol Corp., Cincinnati, OH, S/V, Sound Vib., 11 (11), pp 8-21 (Nov 1977) 21 figs, 4 refs

Key Words: Modal analysis, Transient excitation

This article discusses a technique for experimental structural frequency response testing based upon excitation of the structure with an impulsive force. In many situations, this is the simplest and fastest of the various techniques commonly used today. However, the nature of the excitation and response signals in the impulse technique requires special signal processing techniques if accurate frequency response measurements are to be obtained. This article discusses the application of the impulse technique and reviews the special problems encountered in practice and the techniques that have been developed for dealing with those problems.

COMPUTER PROGRAMS

GENERAL

(See No. 398)

ENVIRONMENTS

ACOUSTIC

(Also see Nos. 462, 463, 464)

78-381

The Radiation Impedance of a Rectangular Piston

P.R. Stepanishen
Dept. of Ocean Engrg., Univ. of Rhode Island, Kingston, RI 02881, J. Sound Vib., 55 (2), pp 275-288 (Nov 22, 1977) 4 figs, 3 tables, 13 refs
Sponsored by the National Inst. of Health

Key Words: Acoustic impedance, Pistons

The radiation impedance of a rectangular piston is expressed as the Fourier transform of its impulse response, which is obtained from the recent work of Lindemann. The analytical evaluation of the transform is performed and new integral expressions are presented for both the radiation resistance and reactance. The integrals are readily evaluated in terms of elementary functions at both the low and high frequency limits. The integrals are also expressed as series of Bessel functions which are valid for all frequencies and aspect ratios. Numerical results are presented to illustrate the behavior of the radiation resistance and reactance as a function of the aspect ratio of the piston and a normalized frequency parameter. Additional numerical results are then presented to illustrate the accuracy of the analytical expressions for the radiation resistance and reactance at low and high frequencies. Finally, numerical resutls are presented to illustrate the application and accuracy of using standard FFT algorithms to evaluate the radiation resistance and reactance directly from the impulse responses.

78-382

Sound Scattering from Thin Shells in the Kirchhoff Approximation

D.W. Brill, P. Uginčius, J. George, F.S. Chwieroth, and H. Überall
U.S. Naval Academy, Annapolis, MD 21402, J. Acoust. Soc. Amer., 62 (6), pp 1367-1372 (Dec 1977) 4 figs, 40 refs

Key Words: Acoustic scattering, Cylindrical shells

The acoustic backscattering cross section of a thin, air-filled elastic cylindrical shell using the Kirchhoff approximation is calculated. The spurious shadow-boundary reflections contained in the conventional formulation of the approximation are removed by the use of the stationary-phase method.

78-383

Absorbing Boundary Conditions for Acoustic and Elastic Wave Equations

R. Clayton and B. Engquist
Dept. of Geophysics, Stanford Univ., Stanford, CA, Bull. Sesimol. Soc. Amer., 67 (6), pp 1529-1540 (Dec 1977) 10 figs, 7 refs

Key Words: Sound waves, Boundary value problems

Boundary conditions are derived for numerical wave simulation that minimize artificial reflections from the edges of the domain of computation. In this way acoustic and elastic wave propagation in a limited area can be efficiently used to describe physical behavior in an unbounded domain. The boundary conditions are based on paraxial approximations of the scalar and elastic wave equations. They are computationally inexpensive and simple to apply, and they reduce reflections over a wide range of incident angles.

78-384

Noise of Individual Vehicles in a High-Rise City

N.W.M. Ko
Dept. of Mech. Engrg., Univ. of Hong Kong, Hong Kong, Japan, J. Sound Vib., 55 (1), pp 39-48 (Nov 8, 1977) 9 figs, 1 table, 11 refs

Key Words: Urban noise, Experimental data, Ground vehicles, Noise generation

Extensive roadside noise measurements of 20,000 vehicles in 100 measurement sites in the high-rise city, Hong Kong, are reported. The vehicles are classified into petrol-powered saloon, diesel-powered saloon, mini-bus and small lorry, and bus and big lorry. The survey was mainly concentrated in the urban areas. Rural areas were also included in the investigation -- such that comparison with the urban areas could be made. The results obtained illustrate the effect of enclosed environment on the noise emitted by the vehicles and support the simple classification of the sites into closed, semi-closed and open envrionments.

78-385

Highway Noise - A Design Guide for Prediction and Control

B.A. Kugler, D.E. Commins, and W.J. Galloway
Bolt Beranek and Newman, Inc., Canoga Park, CA, Rept. No. TRB/NCHRP/REP-174, ISBN-0-309-025-39-7, 203 pp (Dec 1976)
PB-272 450/8GA

Key Words: Traffic noise, Noise reduction, Noise source identification, Computer programs

A set of procedures has been developed and is presented to give highway engineers greater capability in predicting, evaluating, and alleviating traffic-generated noise impacts on the community through highway design practices. The procedures include a manual method using nomographs and a computer program that incorporates plotting routines to identify problem locations. The design guide procedures may be applied both to location or design studies for new highways and to projects involving modifications to existing highways.

78-386

Noise Measurements. Second Interim Report 1974-1975

T. Fuca, V. Gazzillo, and C. Wong
Div. of Res. and Dev., New Jersey Dept. of Transportation, Trenton, NJ, Rept. No. 76-002-7787, FHWA/NJ/RD-76-002-7787, 232 pp (Nov 1975)
PB-270 990/5GA

Key Words: Traffic noise, Noise measurement, Measurement techniques

Noise measurements for 24-hour periods were made at various microphone positions at six sites adjacent to existing roadways. Traffic volume and speed measurements were made simultaneously with noise measurements. The noise measurement sites were surveyed using standard surveying techniques to determine distances and elevations, relative to the roadway, of microphone positions and noise barriers for input into the Michigan Traffic Noise Prediction Program and the Transportation Systems Center Traffic Noise Prediction Program. Noise level predictions were made for each site using the two prediction programs. The measured and predicted noise levels were statistically compared to determine the accuracy of the programs. A method to produce corrections to predicted levels was developed and corrections for the six noise measurement sites were determined.

78-387

Sound Scattering in an Urban Street

R. Bullen
Dept. of Architectural Science, Univ. of Sydney, New South Wales 2006, Australia, Noise Control Engr., 9 (2), pp 54-59 (Sept/Oct 1977) 6 figs, 10 refs

Key Words: Urban noise, Noise reduction

The control of noise from road traffic and aircraft involves sound control at the source, during propagation, and upon entering a building. One aspect of this problem is the need for accurate methods of predicting, and possibly controlling, the sound level resulting from a given source some distance away, in the presence of large built-form structures. The author takes previously developed concepts and methods and extends and applies them to a real situation.

78-388

Noise Generation in High Speed Mechanical Systems

N.D. Perreira
Ph.D. Thesis, Univ. of California, 442 pp (1977)
UM 77-23,913

Key Words: Noise generation, Mechanical systems

A fundamental study of the nature of noise generation in high speed mechanical systems is undertaken. The study develops basic analytical models of the noise generation processes that are brought about in the operation of high speed mechanical systems. The intent of the study is the development of design guidelines which will permit the designer to consider noise as a factor early in his designs. The methods, used to determine the sound pressure in the examples considered, are generalized for the more complex "four bar crank-rocker mechanism". Acoustic power and radiation directivity factors are used to identify a design philosophy. Design guidelines, based on the computer simulations of the four bar mechanism and the impact beam, are then obtained.

RANDOM

(See No. 403)

SEISMIC

78-389

A Macroseismic Study and the Implications of Structural Damage of Two Recent Major Earthquakes in the Jordan Rift

M. Vered and H.L. Striem
Licensing Div., Israel Atomic Energy Commission, P.O. Box 17120, Tel-Aviv, Israel, Bull. Seismol. Soc. Amer., 67 (6), pp 1607-1613 (Dec 1977) 5 figs, 7 refs

Key Words: Earthquake damage

A detailed macroseismic study of an earthquake was carried out. A quantitative analysis of damage data provided a correlation for estimating intensities. Using axis lengths and areas bounded by the ensuing isoseismal lines, the depth of the event was estimated, and its probable epicenter located.

78-390

Response of the Olive View Hospital Main Building during the San Fernando Earthquake

S.A. Mahin, V.V. Bertero, A.K. Chopra, and R.G. Collins

Earthquake Engrg. Res. Center, California Univ., Berkeley, CA., Rept. No. EERC-76-22, 320 pp (Oct 1976)

PB-271 425/1GA

Key Words: Earthquake damage, Seismic design, Hospitals

This report presents the results of an extensive field and analytical investigation of the structural performance of the main building of the Olive View Hospital Medical Treatment and Car Facility during the 1971 San Fernando earthquake.

78-391

Experimental Evaluation of Seismic Design Methods for Broad Cylindrical Tanks

D.P. Clough

Earthquake Engrg. Res. Center, California Univ., Berkeley, CA., Rept. No. UCB/EERC-77/10, 283 pp (May 1977)

PB-272 280/9GA

Key Words: Earthquake damage, Storage tanks, Cylindrical shells, Seismic design

Earthquake damage to ground-supported cylindrical liquid storage tanks during recent years demonstrates the need for better understanding of the seismic behavior of these structures and improvement in seismic design procedures. Analytical procedures epitomizing the current seismic design approach for cylindrical tanks are presented in detail, and their application in a typical design situation is illustrated. Records of tanks damaged in four earthquakes are examined.

78-392

Minimax Procedures for Specifying Earthquake Motion

R.F. Drenick

Polytechnic Inst. of New York, Brooklyn, NY, Rept. No. NSF/RA-761124, 91 pp (Dec 20, 1976)

PB-272 278/3GA

Key Words: Earthquake resistant structures, Minimax technique

This research continues the development of a method which ultimately would enable earthquake engineers to make confident earthquake resistance guarantees. The method, applied to existing structures, leads to assessments of their earthquake resistance.

78-393

On the Safety Provided by Alternate Seismic Design Methods

D.A. Gasparini

Dept. of Civil Engrg., Massachusetts Inst. of Tech., Cambridge, MA., Rept. No. R77-22, 218 pp (July 1977)

PB-271 979/7GA

Key Words: Earthquake resistant structures, Seismic excitation, Multidegree of freedom systems, Buildings, Seismic design

A method is developed for obtaining distributions of responses of elastic multidegree-of-freedom systems to earthquake excitation. Uncertainty in both dynamic model and earthquake excitation parameters is studied. Factors contributing to uncertainty in the strength measures used for rigid frame buildings are examined. A simple frame is designed by elastic criteria and a second moment description of the story strength measures is given.

78-394

Inelastic Dynamic Design of Steel Frames to Resist Seismic Loads

J.H. Robinson, Jr. and J.M. Biggs

Constructed Facilities Div., Massachusetts Inst. of Tech., Cambridge, MA., Rept. No. MIT-CE-R77-23, 143 pp (July 1977)

PB-271 941/7GA

Key Words: Earthquake resistant structures, Seismic design, Buildings

The reliability of an inelastic design procedure based upon elastic modal analysis, using an inelastic response spectrum proposed by Newmark and Hall, is investigated. The effects of P-delta forces, earthquake motion details, assumed damping level, and earthquake intensity were examined.

SHOCK

(Also see No. 428)

78-395

Weak-Shock Solution for Underwater Explosive Shock Waves

R.H. Rogers

Underwater Sound Reference Div., Naval Research Laboratory, Orlando, FL 32806, J. Acoust. Soc. Amer., 62 (6), pp 1412-1419 (Dec 1977) 9 figs, 21 refs

Key Words: Underwater explosions, Shock waves

The initial pressure wave measured at modest distances from an underwater explosion is often modeled as a spherical shock wave with an exponential decay. A closed-form analytical "weak-shock" solution for the subsequent propagation of such a wave has been obtained. The resulting simple formulas for peak pressure and decay constant as function of reduced range allow the prediction of the amplitude and initial slope of the wave given only the amplitude and decay constant of the original exponential shock and the density, sound speed, and parameter of nonlinearity of the water.

78-396

Modular Program Development for Vehicle Crash Simulation. Volume I: Summary Report, Test Results and Theory

I.K. McIvor, W.J. Anderson, and A.S. Wineman

Highway Safety Res. Inst., Michigan Univ., Ann Arbor, MI, Rept. No. UM-HSRI-76-4-1, DOT-HS-802 530, 136 pp (Aug 1977)

PB-272 044/9GA

Key Words: Collision research (automotive), Computer simulation, Automobile bodies, Mathematical models

The objective of the project was to develop a computer simulation for vehicle structures under general crash conditions. The program has a user oriented modular structure designed for maximum flexibility in the synthesis of vehicle models. The volume contains recommendations for future development of vehicle simulations. A description of the general program structure, modeling capability, and solution procedure for the simulation program UMVCS-1 is given. The experimental and predicted results for static and dynamic validation tests are shown. A modeling study of an actual vehicle dynamic frame test is provided.

78-397

Modular Program Development for Vehicle Crash Simulation. Volume II: Plastic Hinge Experiments

W.J. Anderson, I.K. McIvor, and B.S. Kimball

Highway Safety Res. Inst., Michigan Univ., Ann Arbor, MI, Rept. No. UM-HSRI-76-4-2, DOT-HS-802 531, 186 pp (Aug 1977)

PB-272 045/6GA

Key Words: Collision research (automotive), Computerized simulation, Automobile bodies

A large number of full-scale automotive box and channel beams have been tested to observe the formation of plastic hinges. The purpose of the testing was to establish a data bank for moment-angle and force-extension properties of various hinges as a basis for computer simulation of crushing of automobile frames. Some 88 tests were made for extensional, bending and torsional hinges in thin walled tubes. Results are in the form of figures of the load-deflection relationship and tables of parameters used to model the hinge behavior through analytical expressions. In addition, several buckling and combined-load tests were carried out to verify the theory and the computer code which were developed concurrently.

78-398

Modular Program Development for Vehicle Crash Simulation. Volume III. Users' Guide for UMVCS-1

R.O. Bennett, I.K. McIvor, D.H. Robbins, and H.C. Wang

Highway Safety Res. Inst., Michigan Univ., Ann Arbor, MI, Rept. No. UM-HSRI-76-4-3, DOT-HS-802 532, 284 pp (Aug 1977)

PB-272 425/0GA

Key Words: Collision research (automotive), Crashworthiness, Computer programs

This guide is an instruction and information manual to enable the user to prepare an input data set for exercising the program. The guide describes the input quantities which must be provided to the executive section of the program; it also gives a description and sample output of the executive system, a description and sample of the output produced by the computer program, and an example problem including a sample data set and exercise of the program.

TRANSPORTATION

(See No. 464)

PHENOMENOLOGY

FATIGUE

78-399

A Procedure for Calculating Notch- and Geometrical-Effect at Vibratory Loads (ein Verfahren zur Berechnung des Kerb- und Groesseneinflusses bei Schwing-bean-sprunchung)

W. Ziebart

Technische Universität, Munich, West Germany, Rept. No. ICAF-944, 125 pp (Oct 11, 1976)

(In German)

N77-31540

Key Words: Fatigue life, Geometric effects, Vibration excitation

The effects of geometrical shape and size on the fatigue mechanism are explained by defined size, which are distributed at random, by time-varying loading, and by propagation. The mathematical model for first two assumptions leads to a calculation method, with which the life of a component in the finite life ranges predicted in dependence from its geometrical shape and size.

FLUID

(Also see No. 451)

78-400

Probability Distributions Associated with the Wind Loading of Structures

W.H. Melbourne

Dept. of Fluid Mechanics, Monash Univ., Australia, Civ. Engrg. Trans., Instn. of Engr., Australia, 19 (1), pp 58-67 (1977) 9 figs, 1 table, 13 refs

Key Words: Wind-induced excitation, Probability theory

Examples of probability distributions of structures oscillating under wind action have been selected from a number of studies on aero-elastic models tested in a wind tunnel model of the natural wind. Two examples of response are given which illustrate processes which are not normally distributed. One where the variables become significantly dependent, such that the sinusoidal response becomes more regular and the peak factor approaches $\sqrt{2}$, and the other where the process shows intermittent characteristics, which can produce peak factors in excess of 8. The mechanism of local loading on cladding is discussed and examples of probability distributions of pressure from three typical regions are given.

VISCOELASTIC

(See No. 494)

EXPERIMENTATION

DIAGNOSTICS

(Also see No. 379)

78-401

Analytical Single-Plane Balancing

W.T. Settles

Black & Veatch International, Power, 121 (12), pp 76-78 (Dec 1977) 2 figs

Key Words: *Single-plane balancing,* Balancing techniques, Diagnostic techniques

A single-plane balancing method is described for the determination of correction of weight size and placement. The mathematics required can be carried out by an ordinary scientific calculation and some analytical geometry, without resorting to vector graphics.

EQUIPMENT

78-402

Torsional Impact Loading of the Thin-Walled Aluminum Statically Pre-Tensioned

H. Fukuoka, T. Hayashi, N. Tanimoto, and T. Tanaka

Faculty of Engrg. Science, Osaka Univ., Japan, Bull. JSME, 20 (149), pp 1396-1401 (Nov 1977) 16 figs, 5 refs

Key Words: Testing equipment, Bars, Prestressed structures, Torsional response, Experimental data

The experimental studies on the dynamic behavior of a bar pre-stressed axially to the plastic range and submitted to impulsive torsional stresses are reported. The theoretical calculations are also worked out based on the isotropic work hardening assumption and Mises' yield condition.

78-403
The Effects of Vibration on an Aircraft Fuel Density Meter

A. Simpson and W.R. Reynolds
J. Sound Vib., 55 (1), pp 109-133 (Nov 8, 1977) 15 figs, 2 tables, 5 refs

Key Words: Aircraft equipment response, Vibration excitation

Solid friction and backlash in the mechanism of a certain fuel density meter are shown to be instrumental in producing apparent density shifts when the meter is in a dynamical environment. This phenomenon, which is essentially one of rectification of a high frequency input signal, along with a related low frequency oscillatory instability phenomenon, is thought to be new and worthy of extended discussion.

78-404
A Vibrational Analysis of the Fecker Inertial Test Table

G.D. Evans
Frank J. Seiler Research Lab., Air Force Academy, CO, Rept. No. FJ-SRL-TR-77-0014, 26 pp (Aug 1977)
AD-A044 826/6GA

Key Words: Test equipment, Test facilities, Active isolation

An Inertial Test Table is investigated for natural resonant frequencies within the 20-50 Hz range. Extensive alterations to the test table structure caused no changes in amplitude or frequency of the resonances.

FACILITIES

78-405
Basic Design Considerations for Anechoic Chambers

J. Duda
Industrial Acoustics Co., Inc., 1160 Commerce Ave., Bronx, NY 10462, Noise Control Engr., 9 (2), pp 60-67 (Sept/Oct 1977) 12 figs, 10 refs

Key Words: Anechoic chambers, Design techniques

The author discusses the growing need for facilities with a controlled acoustical environment in which measurements can be made accurately and reliably.

78-406
The High Frequency Performance of Wedge-Lined Free Field Rooms

M.E. Delany and E.N. Bazley
Div. of Radiation Science and Acoustics, National Physical Lab., Teddington TW11 0LW, UK, J. Sound Vib., 55 (2), pp 195-214 (Nov 22, 1977) 12 figs, 1 table, 17 refs

Key Words: Test facilities, Acoustic measurement, Wedges

The performance of free field rooms of the type used for precision acoustical measurements has been investigated in the frequency range 1 to 20 kHz. The root-mean-square deviation of the field of a point sound source from the ideal free field value is established as a convenient index of performance. Directly comparable data based on detailed field samplings are presented for a small rectangular enclosure lined with three different wedge treatments, together with data for a large enclosure lined with one of these wedge treatments. Detailed consideration is given to transducer requirements and other factors relating to practical implementation of the test method, and to the effect of wedge imperfections on overall room performance. A theoretical analysis in which the sound scattered from each individual wedge is summed to predict the resultant field at any point within the enclosure is shown to be in good accord with the experimental observations.

INSTRUMENTATION

78-407
Design Method for Ultrasound Transducers using Experimental Data and Computers

R.A. Sigelmann and A. Caprihan
Dept. of Electrical Engrg., Univ. of Washington, Seattle, WA 98195, J. Acoust. Soc. Amer., 62 (6), pp 1491-1501 (Dec 1977) 4 figs, 2 tables, 7 refs

Key Words: Transducers, Diagnostic instrumentation, Computer-aided techniques, Design techniques

An approach is described for designing thickness mode ultrasound transducers. A computer subroutine is used to simulate the frequency response of a transducer in the transmitting or receiving mode. The physical parameters

of the piezoelectric ceramic required for the design are obtained with conventional instrumentation. Two of the parameters are calculated with the aid of a computer program which makes use of the measured impedance versus frequency. An example of design is presented.

TECHNIQUES

(Also see No. 386)

78-408

Non-Destructive Testing for Inelastic Critical Strength

H. Becker
Maxwell Laboratories, Inc., 52 Cummings Park, Woburn, MA, J. Sound Vib., 55 (2), pp 157-163 (Nov 22, 1977) 5 figs, 1 table, 8 refs

Key Words: Nondestructive tests, Buckling, Vibration effects

Non-destructive experimental prediction of the instability strength of a structure has been demonstrated for a few cases. Previous efforts have been restricted to elastic critical strength prediction. A procedure now is suggested for extending the technology to the inelastic range.

COMPONENTS

BEAMS, STRINGS, RODS, BARS

(Also see Nos. 418, 471)

78-409

Effects of a Localized Region of Damage on the Parametric Excitation of a Bar

V.N. Parekh and R.L. Carlson
Lockheed Georgia Co., Marietta, GA 30063, Intl. J. Mech. Sci., 19 (9), pp 547-553 (1977) 2 figs, 9 refs

Key Words: Bars, Parametric excitation, Cracked media, Resonant response

A model for the parametric excitation of a damaged bar is developed. Three parameters characterizing the damaged region: location, size and amount of deterioration are introduced to study the dynamic stability behavior.

78-410

Vibrations of Elliptic Arc Bar Perpendicular to its Plane

S. Takahashi and K. Suzuki
Faculty of Engrg., Yamagata Univ., Yonezawa, Japan, Bull. JSME, 20 (149), pp 1409-1416 (Nov 1977) 8 figs, 5 refs

Key Words: Bars, Curved beams, Vibration response

Vibrations of an elliptic arc bar perpendicular to its plane were investigated. The Lagrangian was reconstructed using a new variable. The equations of motion and the boundary conditions were obtained. Equations of motion in the case of elliptic bar were solved. Frequencies and the modes of vibrations of symmetric elliptic arc bars were represented graphically. Their boundary conditions are built-in, rolled and supported at both ends. This method is also useful to research other curved bars as cosine, catenary and parabolic bars.

78-411

An Automatic Root Searching Myklestad Procedure for Vibration Analysis

B. Dawson and M. Davies
Engrg. Div., Polytechnic of Central London, London W1M 2JS, UK, Mech. and Mach. Theory, 12 (4), pp 363-372 (1977) 3 figs, 3 tables, 7 refs

Key Words: Beams, Natural frequencies, Myklestad method

This paper presented an extension to Myklestad's method that enables the natural frequencies of systems represented by a lumped mass vibrating beam model to be obtained efficiently and automatically, with the exception of these values lying within specified frequency tolerance bandwidths. The method is described and illustrated by determining the first 5 lateral natural frequencies of beams with 2 different types of end-conditions.

78-412

Dynamic Behaviour of a Finite Beam Subjected to Travelling Loads with Acceleration

S.-I. Suzuki
Dept. of Aeronautics, Nagoya Univ., Nagoya, Japan, J. Sound Vib., 55 (1), pp 65-70 (Nov 8, 1977) 5 figs, 12 refs

Key Words: Beams, Moving loads

The dynamic behavior of a finite beam subjected to traveling loads with acceleration is investigated.

78-413
Non-Linear Vibrations of Tapered Cantilevers

G. Prathap and T.K. Varadan
Dept. of Aeronautics, Indian Inst. of Tech., Madras - 600036, India, J. Sound Vib., 55 (1), pp 1-8 (Nov 8, 1977) 4 figs, 2 tables, 9 refs

Key Words: Cantilever beams, Variable cross section, Nonlinear theories

By means of a variable separable assumption, an eigenvalue-like problem is formulated for the non-linear free flexural vibrations of a cantilever beam. This eigenvalue problem is solved by a simple, relatively straightforward computational technique that provides an exact numerical solution to the problem, without any further asusmptions as to the mode shape or periodicity of the time function.

78-414
Vibrations of Timoshenko Frames with Flexible Joints

I. Yaghmai
Ph.D. Thesis, Univ. of Minnesota, 206 pp (1976) UM 77-12,878

Key Words: Framed structures, Timoshenko theories

This model contains distributed parameter beam elements which deform axially, bending and shear. An equivalent rotary spring at both ends of the beam accounts for the influence of combined bending and shear deformation of the joint, while longitudinal end springs account for axial flexibility of the joints. A finite end spring length is specified to include the effect of joint geometric size.

BEARINGS

78-415
Stiffness and Damping Coefficients of an Inclined Journal Bearing

A. Mukherjee and J.S. Rao
Dept. of Mech. Engrg., Indian Inst. of Tech., Kharagpur-2, India, Mech. and Mach. Theory, 12 (4), pp 339-355 (1977) 9 figs, 13 refs

Key Words: Fluid-film bearings, Journal bearings, Stiffness coefficients, Damping coefficients

In the determination of the dynamic behavior of a rotating shaft, the fluid film stiffness and damping coefficients of the bearings play an important role. The general practice is to ignore the rotational stiffnesses and damping coefficients due to the tilt of the journal in the bearing. This paper presents the stiffness and damping coefficients of journal bearings. Using the expression for film thickness, the modified Reynolds' Equation for the tilted finite journal bearing is set up. The solution of this equation for the film pressure is obtained by using Fedor's proportionality hypothesis. The results obtained are presented in the form of non-dimensional charts.

78-416
A Variational Solution of Two Lobe Bearings

D.V. Singh, R. Sinhasan, and A. Kumar
Dept. of Mech. and Industrial Engrg., Univ. of Roorkee, Roorkee 247667, India, Mech. and Mach. Theory, 12 (4), pp 323-330 (1977) 6 figs, 1 table, 9 refs

Key Words: Fluid-film bearings, Bearings, Variational methods

Non-circular bearings are finding extensive use in high speed machinery as they enhance shaft stability, reduce power losses and increase oil flow (as compared to circular bearings), thus reducing bearing temperatures. Elliptical bearings are among the commonly used non-circular bearings. In this paper, a solution using a variational approach has been presented to analyze elliptical bearings. The results of an elliptical bearing actually in use in a 110 mW turbo-set have been compiled.

BLADES

78-417
Vibration Analysis of Steam Turbine Discs

K. Eswaran, K. Ganapathi, and H. Srinath
Bharat Heavy Electricals Limited Unit: Res. and Dev., Hyderabad-500 003, India, Mech. and Mach. Theory, 12 (4), pp 357-362 (1977) 4 figs, 1 ref

Key Words: Discs, Blades, Steam turbines, Flexural vibration

A knowledge of the vibration characteristics of discs of steam turbines is a prerequisite for a successful design of the turbine. As a matter of fact, considerable research effort, both theoretical and experimental, has been directed towards understanding the dynamic behavior of blades and discs taken singly and jointly. This paper presents a theoretical analysis of the vibration characteristics of a steam turbine disc. In particular, the Runge-Kutta method has been used to solve the differential equation governing the flexural oscillations of the disc. Numerical results evaluated for a typical disc are presented.

78-418

Vibrations of Rotating, Pretwisted and Tapered Blades

M. Swaminathan and J.S. Rao

Propulsion Div., National Aeronautical Lab., Bangalore-17, India, Mech. and Mach. Theory, 12 (4), pp 331-337 (1977) 3 figs, 8 refs

Key Words: Turbomachinery blades, Variable cross section, Cantilever beams, Variable cross section, Natural frequencies

In this paper, turbomachinery blades are idealized as rotating pretwisted and tapered cantilever beams with rectangular cross-section. Expressions for potential and kinetic energy of such beams are derived and the Lagrangian function obtained thereupon is minimized according to the Ritz process. Pretwist, rotation and decreasing width taper are shown to have considerable influence on the flexural frequencies of the beams considered.

78-419

Coupled Bending-Torsional Vibrations of Rotating Cantilever Blades - Method of Polynomial Frequency Equation

J.S. Rao and S. Banerjee

Dept. of Mech. Engrg., Indian Inst. of Tech., New Delhi-110029, India, Mech. and Mach. Theory, 12 (4), pp 271-280 (1977) 3 figs, 31 refs

Key Words: Turbomachinery blades, Coupled response, Torsional vibration, Flexural vibration, Frequency equation

In this paper a polynomial frequency equation method is developed to determine the natural frequencies of a cantilever blade with an asymmetric cross-section mounted on a rotating disc. Considering the blade as a discrete system, generalized polynomial expressions for the slope, linear and angular deflections are derived, using Myklestad expressions with necessary modifications. With these polynomial expressions, the polynomial frequency equation of the system is set up which can be solved to determine the natural frequencies of the system.

78-420

Comparison of Some Optimal Control Methods for the Design of Turbine Blades

B.M.E. DeSilva and G.N.C. Grant

Dept. of Mathematics, Loughborough Univ. of Tech., UK, Rept. No. MATHS-Res-96, 55 pp (Apr 1976)
N77-31166

Key Words: Turbine blades, Beams, Timoshenko theory, Structural synthesis

Some numerical methods for the optimal control design of turbine blades, the vibration characteristics of which are approximated by Timoshenko beam idealizations with shear and incorporating simple boundary conditions, were compared. The blade was synthesized using the following methods: conjugate gradient minimization of the system Hamiltonian in function space incorporating penalty function transformations; projection operator methods in a function space which includes the frequencies of vibration and the control function; epsilon-technique penalty function transformation resulting in a highly nonlinear programming problem; finite difference discretization of the state equations again resulting in a nonlinear program; second variation methods with complex state differential equations to include damping effects resulting in systems of inhomogeneous matrix Riccati equations some of which are stiff; quasilinear methods based on iterative linearization of the state and adjoint equation.

78-421

Vibration Analysis of Rotor Blades with an Attached Concentrated Mass

V.R. Murthy and P.S. Barna

Old Dominion Univ. Research Foundation, Norfolk, VA., Rept. No. NASA-CR-154987, 191 pp (Aug 1977)
N77-31537

Key Words: Rotor blades, Helicopter rotors, Natural frequencies, Mode shapes

The effect of an attached concentrated mass on the dynamics of helicopter rotor blades is determined. The point transmission matrix method was used to define, through three completely automated computer programs, the natural vibrational characteristics (natural frequencies and mode shapes) of rotor blades. The problems of coupled flapwise bending, chordwise bending, and torsional vibration of a twisted nonuniform blade and its special subcase pure torsional vibration are discussed. The orthogonality relations that exist between the natural modes of rotor blades with an attached concentrated mass are derived. The effect of pitch, rotation, and point mass parameters on the collective, cyclic, scissor, and pure torsional modes of a seesaw rotor blade is determined.

78-422

Acoustically Swept Rotor

F.H. Schmitz, D.A. Boxwell, and C.R. Vause

Army Air Mobility R&D Lab., Moffett Field, CA, US-Patent-Appl-SN-831633, 36 pp (Sept 8, 1977)
Sponsored by NASA
N77-31130

Key Words: Rotor blades, Noise reduction

Impulsive noise reduction is provided in a rotor blade by acoustically sweeping the chord line from root to tip so that the acoustic radiation resulting from the summation of potential singularities used to model the flow about the blade tend to cancel for all times at an observation point in the acoustic far field.

DUCTS

78-423

Radiation of Sound from a Two-Dimensional Acoustically Lined Duct

W. Koch

Institut f. Strömungsmechanik, DFVLR/AVA Göttingen, Federal Rep. of Germany, J. Sound Vib., 55 (2), pp 255-274 (Nov 22, 1977) 8 figs, 29 refs

Key Words: Ducts, Acoustic linings, Sound transmission loss, Sound waves

The radiation of sound from the open end of a semi-infinite two-dimensional duct lined on both inner side walls with a locally reacting, sound absorbing material of finite length is investigated analytically by means of the generalized Wiener-Hopf technique for zero mean flow. The analytical results for the power transmission loss and the radiation pattern are evaluated numerically and displayed for several parameter variations.

FRAMES, ARCHES

(Also see No. 410)

78-424

Determining the Amplitudes of Resonance Vibrations of a T-Shaped Frame Taking into Consideration Constraint Equations (Wyznaczanie amplitud drgan rezonansowych ramy w ksztalcie litery t przy uwzglednieniu rownan wiezow)

S. Kotowski and A. Olas

Polish Academy of Sciences, Warsaw, Poland, 24 pp (Nov 25, 1976)

(In Polish)

N77-31531

Key Words: Free vibration, Frames

The frequency of free vibrations of a T-shaped frame node and the amplitudes of resonance vibrations of the frame at selected points are determined. A method of rigid finite elements of complementation which is reduced to an algorithm by admission of constraint equations is presented.

MEMBRANES, FILMS, AND WEBS

78-425

Transient Response of a Circular Membrane to an Eccentric Annular Impact Load

K. Nagaya

Dept. of Mech. Engrg., Yamagata Univ., Yonezawa, Japan, J. Sound Vib., 55 (2), pp 215-223 (Nov 22, 1977) 8 figs, 14 refs

Key Words: Circular membranes, Transient response

In this paper a method of solving vibration problems for a circular membrane subjected to an eccentric annular impact load is presented. In the analysis use is made of the exact solution for the equation of motion of the circular membrane referred to an origin at the center of the eccentric load, and the outer boundary conditions of the membrane are satisfied by using the Fourier expansion method. Some numerical results are given for exponentially decaying eccentric and concentric annular loads, respectively. For a representative case in which the eccentricity of the load is zero, the results obtained are compared with those obtained by exact methods.

PANELS

78-426

Stability and Vibration of Thin Rectangular Plates by Simplified Mixed Finite Elements

J.N. Reddy and C.S. Tsay

School of Aerospace, Mech. and Nuclear Engrg., The Univ. of Oklahoma, Norman, OK 73019, J. Sound Vib., 55 (2), pp 289-302 (Nov 22, 1977) 3 figs, 9 tables, 31 refs

Sponsored by the National Science Foundation

Key Words: Rectangular plates, Finite element technique, Transient response

Rectangular finite elements based on a Reissner type variational statement for plate bending are applied to stability and free vibration of rectangular plates. The finite elements are constructed from the weak statements of the two normal moment-displacement relations and the moment equilibrium

equation in terms of the two normal moments. These finite elements are algebraically simple and yield better accuracies for the critical loads and natural frequencies when compared to conventional finite elements. Linear and quadratic rectangular finite elements are used to calculate frequencies and buckling loads of rectangular plates with various edge conditions.

PIPES AND TUBES

78-427

Control Valve and Regulator Noise Generation, Propagation, and Reduction

G. Reethof

Dept. of Mech. Engrg., Pennsylvania State Univ., University Park, PA 16802, Noise Control Engr., 9 (2), pp 74-85 (Sept/Oct 1977) 11 figs, 1 table, 42 refs

Key Words: Pipes (tubes), Noise generation, Noise reduction

One of the major noise sources in the chemical, petrochemical, and steam power generation industries are the control valves and regulators. The author describes the noise generation mechanisms in these energy dissipation devices, propagation inside the pipes, and acoustic transmission through the pipe walls. Many noise reduction techniques are presented, and their relative merits are discussed.

PLATES AND SHELLS

(Also see Nos. 391, 437, 438)

78-428

An Impact of a Fluid-Filled Spherical Shell with a Shallow Spherical Shell of Larger Radius: A Model for Head Injury

J.O. Oladunni

Ph.D. Thesis, The Ohio State Univ., 224 pp (1977) UM 77-24,680

Key Words: Shells, Fluid-filled containers, Head (anatomy), Mathematical models, Collision research (automotive)

A mathematical modeling of a nonpenetrated type of head impact process in a crash involving a moving vehicle at speeds of 10 mph and 50 mph is investigated. For the impact aspect of the collision, the skull and the brain are modeled by a thin elastic shell and inviscid fluid whose density is very close to that of the brain. The impacted windshield is modeled as a shallow shell of much larger radius. The solution of the resulting equations enables determination of the locations of brain damage and skull fracture.

78-429

Torsional Vibrations of Some Layered Shells of Revolution

K. Chandrasekaran

Dept. of Aeronautical Engrg., Indian Inst. of Tech., Madras 600036, India, J. Sound Vib., 55 (1), pp 27-37 (Nov 8, 1977) 9 figs, 4 tables, 4 refs

Key Words: Shells of revolution, Torsional vibration, Natural frequencies, Mode shapes, Geometrical effects, Stiffness coefficients

Free torsional vibrations of some layered shells of revolution are studied. The frequencies and mode shapes corresponding to the first few modes of vibration of shells with different edge-fixity conditions are presented. The effects of the thickness of the shells and of the stiffness parameters are analyzed.

78-430

Vibration of Simply-Supported Plates of Arbitrary Shape Carrrying Concentrated Masses and Subjected to a Hydrostatic State of In-Plane Strcsses

P.A.A. Laura and R.H. Gutierrez

Inst. of Appl. Mechanics, Base Naval Puerto Belgrano, Argentina, J. Sound Vib., 55 (1), pp 49-53 (Nov 8, 1977) 4 figs, 12 refs

Key Words: Plates, Eigenvalue problems, Conformal mapping, Variational methods

The title problem is solved by using a conformal mapping-variational method. The calculated eigenvalues are in good agreement with those obtained by using a finite element approach. The problem is of practical importance since the knowledge of the dynamic behavior of odd-shaped plates is of great interest in the design of electronic packages containing printed circuit boards.

78-431

Effects of Aspect Ratio on Parametric Response of Nonlinear Rectangular Plates - Analysis and Experiment

G.L. Ostiguy

Ph.D.Thesis, Syracuse Univ., 421 pp (1976) UM 77-24,401

Key Words: Rectangular plates, Parametric response

Analysis and experiments are carried out to determine the stability characteristics and the stationary and nonstationary parametric responses of simply-supported rectangular plates with various aspect ratios which are subjected to the action of periodic in-plane forces uniformly distributed along two opposite edges.

78-432

Nonlinear Dynamic Analysis of Flat Plate Layered Bodies Accounting for Large Transverse Deflections

P.J.C. Van Blaricum

Ph.D. Thesis, Univ. of Illinois at Urbana-Champaign, IL, 93 pp (1977)
UM 77-26,772

Key Words: Plates, Finite element technique

A finite element model for the stress and displacement analysis of laminated orthotropic thick plate structures is described taking advantage of the plate-like nature of the problem. Plasticity and large deflection effects are included in the analysis. The mass of the structure is assumed to be lumped at the finite element nodes. The resulting matrix dynamic equation is solved using a numerical time integration method.

RINGS

78-433

Retaining Rings for Shafts Rotating at High Speeds

R. Hübener

Seeger-Orbis, Ball Bearing J., 193, pp 22-24 (Oct 1977) 3 figs

Key Words: Rings, Shafts

A retaining ring mounted on a shaft can lose its grip if it rotates too quickly and may subsequently lead to damage. The proper use at high speeds and modifications of the design of retaining rings, particularly of Seeger rings, is presented.

STRUCTURAL

78-434

Earthquake Resistant Structural Walls. Tests of Isolated Walls

R.G. Oesterle, A.E. Fiorato, L.S. Johal, J.E. Carpenter, and H.G. Russell

Res. and Dev. Construction Tech. Labs., Portland Cement Association, Skokie, IL, Rept. No. PCA-R/D-Ser-1571, NSF/RA-760815, 321 pp (Nov 1976)
PB-271 467/3GA

Key Words: Earthquake resistant structures, Walls, Testing techniques, Experimental data, Reinforced concrete

The behavior of structural walls for use in earthquake resistant buildings is being studied experimentally. Isolated reinforced concrete walls are being subjected to reversing, in plane, lateral loads. The overall objective is to develop designs to insure adequate inelastic performance. This report describes the test program and the results from the first nine wall tests. Variables included shape of the wall cross section, amount of flexural reinforcement, and the use of confined boundary elements. One wall was subjected to monotonic loads and one wall was repaired and retested.

78-435

Optimum Structural Design with Frequency and Size Constraints

D.J. Vavrick

Ph.D. Thesis, Univ. of Minnesota, 247 pp (1977)
UM 77-26,170

Key Words: Structural elements, Cylinders, Beams, Sandwich structures, Torsional vibration, Flexural vibration

The principle of Pontryagin is used to establish the necessary conditions and their relationship for these four optimum design problems: either minimize or maximize the weight of a simple structure subject to frequency and size constraints and either minimize or maximize any single frequency of the structure subject to a total weight constraint and to thickness and other frequency constraints. The structures considered were simple one-dimensional structural elements with various boundary conditions: thin-walled cylinders in torsional oscillation and Euler-Bernoulli and Timoshenko sandwich beams in flexural vibration. The optimum structural design involves the solution of nonlinear two-point boundary value problems which was accomplished numerically, except in a few cases where analytic solutions were possible.

TIRES

78-436

A Technique for Measuring the Sound of a Moving Tire

J.Y. Chung and I.D. Wilken
Fluid Dynamics Res. Dept., General Motors Res. Labs, General Motors Tech. Center, Warren, MI 48090, J. Sound Vib., 55 (1), pp 9-18 (Nov 8, 1977) 8 figs, 4 refs

Key Words: Tires, Noise measurement

A measurement and analysis technique has been developed to determine the narrow band spectra and the radiation patterns of the sound emitted by a moving tire. The sound is measured by a semicircular array of stationary microphones as the tire passes by the array and is recorded on a multi-channel tape recorder. In the analysis procedure corrections are made for effects associated with a moving sound source, such as the non-stationarity of the signal due to the time-dependent transmission path and the Döppler frequency shifts. In this way the power spectra and the radiation pattern of the sound signal are determined as if the receiver were moving with the tire at a fixed distance. A relationship between the Döppler effect and the frequency resolution associated with the finite Fourier transform is presented. This relation is used as a basis for the Döppler correction procedure.

78-437
A Finite Element Analysis of the Static and Dynamic Behavior of the Automobile Tire
P.D. Parikh
Ph.D. Thesis, Texas Tech Univ., 148 pp (1977) UM 77-25,512

Key Words: Automobile tires, Tires, Shells of revolution, Stiffness methods, Finite element technique, Mathematical models, Natural frequencies, Mode shapes

A mathematical model to represent a radial ply passenger car tire has been developed for axisymmetric and asymmetric static and dynamic eigenvalue analysis by the use of a direct stiffness finite element method. The tire is considered as a thin shell of revolution. The analysis predicts experimentally verifable deformed shapes under static loading, and natural frequencies of vibration and associated mode shapes with good accuracy.

78-438
A Mathematical Treatment of the Radial Tire Modeled as a Rotating Cylindrical Shell on an Elastic Foundation
T.K. Roy
Ph.D. Thesis, Texas Tech Univ., 182 pp (1977) UM 77-25,517

Key Words: Automobile tires, Tires, Cylindrical shells, Elastic foundations, Mathematical models, Natural frequencies, Mode shapes

A mathematical model has been developed which adequately represents the static and dynamic behavior of a radial tire. The tire has been treated as a rotating cylindrical shell on an elastic foundation. The motion has been restricted to the plane of the tire only. The principle of minimum energy is employed to derive the equations of motion. Both free and forced vibration cases are discussed. An expression for the natural frequencies has been obtained.

78-439
The Steering Torque Properties of Single-Track Vehicles in Steady Turning
H. Fu
College of Science & Technology, Nihon Univ., Chiyoda-ku, Tokyo, Japan, Bull. JSME, 20 (149), pp 1431-1437 (Nov 1977) 9 figs, 12 refs

Key Words: Steering effects, Cornering effects, Tire dynamics, Ground vehicles

Except for the steering torque, analyses have been conducted previously on the characteristics of a single-track vehicle in steady turning. This paper introduces the equation of a steering torque taking into account the camber torque and the section radius of the tire.

SYSTEMS

ABSORBER

78-440
A Study of the Characteristics of Automotive Hydraulic Dampers at High Stroking Frequencies
H.H. Lang
Ph.D. Thesis, The Univ. of Michigan, 254 pp (1977) UM 77-26,288

Key Words: Hydraulic dampers, Shock abosrbers

This dissertation is concerned with the determination of the characteristics of the damping forces generated by the operation of automotive type shock absorbers in the frequency range of 1 to 10 Hz and with amplitudes up to ± 2 inches

and the development of a fundamental understanding of the phenomena that cause the dynamic behavior. The approach used, involves the development of a mathematical model of shock absorber performance based upon the dynamic pressure-flow characteristics of the shock absorber fluid and the dynamic action of the valves. This model is then programmed on an analog computer.

NOISE REDUCTION

(Also see Nos. 387, 422, 466, 467, 475, 476, 477)

78-441

Finite Element Acoustical Analysis of Complex Muffler Systems With and Without Wall Vibrations

C.J. Young and M.J. Crocker

Engrg. Res. and Dev. Div., E.I. duPont de Nemours and Co., Wilmington, DE 19898, Noise Control Engr., 9 (2), pp 86-93 (Sept/Oct 1977) 13 figs, 11 refs

Key Words: Mufflers, Mathematical models, Finite element technique

In creating a new complicated exhaust muffler, designers usually experiment with a large number of configurations. To reduce the required development and testing, a cost-effective design method must be based on a satisfactory theoretical model. Using the finite element technique developed by the authors either single-cavity or multi-cavity mufflers can easily be analyzed and designed.

ACTIVE ISOLATION

(See No. 404)

AIRCRAFT

(Also see No. 403)

78-442

The Transonic Oscillating Flap: A Comparison of Calculations with Experiments

R. Magnus and H. Yoshihara

General Dynamics/Convair, San Diego, CA., In: AGARD Unsteady Airloads in Separated and Transonic Flow, 5 pp (Apr 1977)

N77-31086

Key Words: Airfoils, Oscillation

Finite difference calculations based on the exact inviscid equations for an oscillating flap on an airfoil are compared to the Tijdeman-Schippers experimental results. Viscous effects were incorporated in a phenomenological manner using viscous displacement ramps. Reasonably good agreement was obtained, but with a significant discrepancy in the shock motions attributable to a mismatch in the surface pressures upstream of the shock.

78-443

Unsteady Airloads on an Oscillating Supercritical Airfoil

N. Tijdeman, P. Schippers, and A.J. Pearsoon

National Aerospace Lab., Amsterdam, Netherlands, In: AGARD Unsteady Airloads in Separated and Transonic Flow, 15 pp (Apr 1977)

N77-31085

Key Words: Airfoils, Oscillation

Results are presented of unsteady pressure measurements on a two-dimensional model of the supercritical NLR 7301 airfoil performing pitching oscillations about an axis at 40 per cent of the chord.

78-444

A Brief Overview of Transonic Flutter Problems

W.J. Mykytow

Dynamics Lab., Air Force Flight Dynamics Lab., Wright-Patterson AFB, OH, IN: AGARD Unsteady Airloads in Separated and Transonic Flow, 13 pp (Apr 1977)

N77-?1084

Key Words: Aircraft, Flutter, Model testing

A framework of industrial flutter problems with particular emphasis on the impact for the speed region is provided. Flutter stability boundaries are given re-emphasizing the critical design conditions present in the transonic flight region. The re-emphasis is accomplished using results from research flutter model tests, aircraft design, and development model tests, and aircraft flight damping measurements.

78-445

Flutter Calculation for the Viggen Aircraft with Allowance for Leading Edge Vortex Effect

Aerospace Div., Saab-Scania, Linkoping, Sweden, In: AGARD Unsteady Airloads in Separated and Transonic Flow, 7 pp (Apr 1977)

N77-31083

Key Words: Aircraft, Flutter

An application in a flutter calculation for the Viggen aircraft of a program system for aeroelastic calculations is briefly described. The result which is checked against an independent calculation shows that a large flutter margin exists. For increasing angle of incidence, however, the margin may decrease due to the effect of the leading edge vortices. An estimate of the decrease was obtained by applying a correction factor based on measured pressure distributions for steady flow to the calculated lift distribution.

78-446

Investigation of Flight Dynamics During Roll (Untersuchung der Flugdynamik beim Rollen)

H.D. Finck and G. Sachs

Inst. f. Flugtechnik, Technische Hochschule, Darmstadt, West Germany, Rept. No. IFD-8/76, 58 pp (Apr 5, 1976)

(In German)

N77-31177

Key Words: Aircraft, Dynamic response, Computer programs

The dynamics of a highly maneuverable subsonic aircraft during multiple roll around the length axis were investigated with a 6 deg of freedom model. The nonlinear dependencies on the aerodynamic forces and moments are taken into account. The effect of the dynamic derivation of lateral motion on the overall motion is shown. The relationship between the position of the overall rotation vector and the velocity vector is represented.

78-447

Unsteady Airloads in Separated and Transonic Flow

C.L. Bore

Hawker Siddeley Aviation Ltd., Kingston upon Thames, UK, In: AGARD Unsteady Airloads in Separated and Transonic Flow, 9 pp (Apr 1977)

N77-31074

Key Words: Aircraft, Dynamic response

The papers dealing with unsteady loads arising from separated flow that were presented at the AGARD Fluid Dynamics Panel's symposium on Prediction of Aerodynamic loading are reviewed. The principal topics discussed include dynamic phenomena arising from aircraft maneuvers transient dynamic stall loads, and methods for predicting buffet.

78-448

The Dynamic Response of Wings in Torsion at High Subsonic Speeds

G.F. Moss and D. Pierce

Aerodynamics Dept., Royal Aircraft Establishment, Farnborough, UK, In: Agard Unsteady Airloads in Separated and Transonic Flow, 21 pp (Apr 1977)

N77-31077

Key Words: Aircraft wings, Dynamic response, Aerodynamic excitation

The structural response of aircraft wings to aerodynamic excitation at conditions appropriate to maneuvers at high subsonic speeds is discussed. Reference is made to wind tunnel experiments using models specially designed to deform under test in a realistic way as well as 'rigid' models of conventional construction. The primary torsion mode of vibration of the wings tended to be strongly excited under some aerodynamic flow conditions on the flexible models used, and in some cases the amplitude was large and similar to single-degree-of-freedom flutter in character. Data from some slight tests is quoted to demonstrate that this type of response may well occur in practice.

78-449

Subsonic and Supersonic Longitudinal Stability and Control Characteristics of an Aft-Tail Fighter Configuration with Cambered and Uncambered Wings and Cambered Fuselage

S.M. Dollyhigh

Langley Res. Center, NASA, Langley Station, VA., Rept. No. NASA-TN-D-8472; L-11424, 79 pp (Sept 1977)

N77-31093

Key Words: Aircraft, Aerodynamic characteristics

The longitudinal aerodynamic characteristics of a fighter airplane concept has been determined through an investigation over a Mach number range from 0.50 to 2.16. The configuration incorporates a cambered fuselage with a single external compression horizontal ramp inlet, a clipped arrow wing, twin horizontal tails, and a single vertical tail. The wing camber surface was optimized in drag due to lift and was designed to be self trimming at Mach 1.40 and at a lift coefficient of 0.20. The fuselage was cambered to preserve the design wing loadings on the part of the theoretical wing enclosed by the fuselage. An uncambered of flat wing of the same planform and thickness ratio distribution was also tested.

78-450

Prediction of Transonic Aircraft Buffet Response

A.M. Cunningham, Jr. and D.B. Benepe, Sr.

General Dynamics, Fort Worth, TX, IN: AGARD Unsteady Airloads in Separated and Transonic Flow, 21 pp (Apr 1977)
N77-31076

Key Words: Aircraft, Wind-induced excitation

A method for predicting aircraft buffet response is briefly reviewed. The method is applied to a variable sweep fighter aircraft and predicted results are compared with flight test data. The types of buffeting flow considered for various wing sweep angles include separated and vortex flows as well as oscillating shocks. The current method is compared with three other methods in the correlation with flight test data. The inherent scatter of flight data is discussed as well as probable sources of the scatter. A mechanism is described by which wing torsional motion and shock oscillation couple to produce relatively severe buffeting conditions at a forward wing sweep. The importance of considering buffet fatigue damage on secondary structure is discussed.

78-451

A Comparison of the Results of Dynamic Wind-Tunnel Tests with Theoretical Predictions for an Aeromechanical Gust-Alleviation System for Light Airplanes

E.C. Stewart and L.T. Redd

Langley Research Center, NASA, Langley Station, VA., Rept. No. NASA-TN-D-8521; L-11352, 47 pp (Sept 1977)
N77-31072

Key Words: Aircraft, Wind-induced excitation, Wind tunnel tests

Dynamic wind tunnel tests have been conducted on a 1/6-scale model of a general aviation airplane equipped with an all-mechanical gust alleviation system which uses auxiliary aerodynamic surfaces to drive the flaps. The longitudinal short period motions were studied under simulated gust conditions in order to verify the mathematical model used in a previous study to predict the performance of the full scale system and determine the amount of normal acceleration alleviation which could be attained. The model responses were measured for different configurations with the system active and without the system active for comparison.

78-452

Vibroacoustic Response of Structures and Perturbation Reynolds Stress Near Structure-Turbulence Interface

S. Maekawa and Y.K. Lin

Illinois Univ., Urbana-Champaign, IL, Rept. No. NASA-CR-2876, 116 pp (Sept 1977)
N77-31543

Key Words: Aircraft, Fluid-induced excitation

The interaction between a turbulent flow and certain types of structures which respond to its excitation is investigated. One-dimensional models were used to develop the basic ideas applied to a second model resembling the fuselage construction of an aircraft. In the two-dimensional case a simple membrane, with a small random variation in the membrane tension, was used. A decaying turbulence was constructed by superposing infinitely many components, each of which is convected as a frozen pattern at a different velocity. Structure-turbulence interaction results are presented in terms of the spectral densities of the structural response and the perturbation Reynolds stress in the fluid at the vicinity of the interface.

78-453

Separated-Flow Unsteady Pressures and Forces on Elastically Responding Structures

C.F. Coke, D.W. Riddle, and C. Hwang

Ames Res. Center, NASA, Moffett Field, CA., In: AGARD Unsteady Airloads in Separated and Transonic Flow, 25 pp (Apr 1977)
N77-31075

Key Words: Aircraft, Fluid-induced excitation

Broadband root-mean-square, spectral density, and spatial correlation information that characterizes the fluctuating pressures and forces that cause aircraft buffet is presented. The main theme is to show the effects of elasticity. In order to do so, data are presented that were obtained in regions of separated flow on wings of wind-tunnel models of varying stiffness and on the wing of a full-scale aircraft. Reynolds number effects on the pressure fluctuations are also discussed.

78-454

Airframe Response to Separated Flow on the Short Haul Aircraft VFW 614

H. Zimmermann and G. Krenz

Vereinigte Flugtechnische Werke G.m.b.H., Bremen, West Germany, In: AGARD Unsteady Airloads in Separated and Transonic Flow, 9 pp (Apr 1977)
N77-31081

Key Words: Aircraft, Fluid-induced excitation

Using the VFW 614 aircraft as an example the influence of an intermittent jet flow on sub-structures outside known jet

boundaries is illustrated. Effects comparable to those due to the engine jet are caused also by the wake of movable wing parts such as spoilers and airbrakes. The VFW 614 is used again as an example to illustrate the occurrence of horizontal tail buffet due to flow disturbances for outside the spoiler wake region, and to describe the steps taken to eliminate this type of buffet. Several examples of flow separation with ensuing buffeting which typically occur in the course of flight trials, and measures to combat these disturbances are discussed.

78-455

Dynamic Loading of Airframe Components

C.G. Lodge and M. Ramsey
Military Aircraft Div., British Aircraft Corp., Preston, UK, In: AGARD Unsteady Airloads in Separated and Transonic Flow, 26 pp (Apr 1977)
N77-31080

Key Words: Aircraft, Fatigue life

The design of modern combat aircraft is discussed in terms of structural fatigue life. Unsteady loads due to separated flow conditions in maneuvering flight are examined. Dynamic loads on a modern variable sweep wing combat aircraft are predicted making use of wing tunnel model tests and results from flight tests. The predictions are compared with available prototype flight measurements.

78-456

Tail Response to Propeller Flow on a Transport Airplane

L. Chesta
Aeritalia S.p.A., Torino, Italy, In: AGARD Unsteady Airloads in Separated and Transonic Flow, 13 pp (Apr 1977)
N77-31082

Key Words: Aircraft, Vibration source identification, Vibration effects, Fatigue life

The results of a flight investigation on tail vibrations on transport aircraft and the measures taken to overcome the subsequent problems are described. Factors studied include the source of vibrations; the flight conditions in which they occur; and the impact of the vibration level on the fatigue life.

78-457

Evaluation of Vibration Levels at the Pilot Seat Caused by Wing Flow Separation

J. Becker and K. Dau
Messerschmidt-Boelkow G.m.b.H., Munich, West Germany, In: AGARD Unsteady Airloads in Separated and Transonic Flow, 28 pp (Apr 1977)
N77-31078

Key Words: Aircraft seats, Vibration measurement

Examples of the evaluation of vibration levels on the pilot seat are presented. The first deals with the results of low speed measurements on a strake wing model with and without flap and slats, including the effect of leading edge blowing, in the incidence region 0 less than or equal to alpha less than or equal to 90 deg. The second example demonstrates the results obtained by the method based on measurements of fluctuating pressures on rigid models for two configurations with 25 and 45 degree wing sweep in the high subsonic region.

78-458

A Practical Framework for the Evaluation of Oscillatory Aerodynamic Loading on Wings in Supercritical Flow

H.C. Garner
Structures Dept., Royal Aircraft Establishment, Farnborough, UK, In: AGARD Unsteady Airloads in Separated and Transonic Flow, 15 pp (Apr 1977)
N77-31089

Key Words: Aircraft wings, Oscillation

An approximate theoretical treatment is devised in terms of nonlinear steady surface pressure and linear oscillatory loading. The steady data are taken either from transonic small perturbation theory or from static measurements of surface pressure. The resulting theoretical or semi-empirical method can take account of stream Mach number, mean incidence, mode of oscillation, frequency and amplitude. The calculations are organized into a computer program, the scope and broad details of which are outlined.

78-459

Application of a Finite Difference Method to the Analysis of Transonic Flow Over Oscillating Airfoils and Wings

W.H. Weatherill, J.D. Sebastian, and F.E. Ehlers
Flutter Res. Group, Boeing Commercial Airplane Co., Seattle, WA., In: AGARD Unsteady Airloads in Separated and Transonic Flow, 13 pp (Apr 1977)
N77-31090

Key Words: Airfoils, Aircraft wings, Finite difference theory

A finite difference method for solving the unsteady flow about harmonically oscillating wings is investigated. The procedure is based on separating the velocity potential into steady and unsteady parts and linearizing the resulting unsteady differential equation for small disturbances. Solutions are obtained using relaxation procedures. The means for improving the solution stability characteristics of the relaxation process are explored. A direct procedure is formulated which permits obtaining solutions for combinations of Mach number and reduced frequency for which the relaxation process has proved unstable. The pressure distribution for an aspect ratio 5 rectangular wing oscillating in pitch is presented.

BRIDGES

78-460

A Modal Method for Calculation of Highway Bridge Response with Vehicle Braking

H. Kishan and R.W. Traill-Nash

Dept. of Civil Engrg., Univ. of New South Wales, Australia, Civ. Engrg. Trans., Instn. of Engr., Australia, 19 (1), pp 44-50 (1977) 6 figs, 1 table, 11 refs

Key Words: Bridges, Interaction: vehicle-terrain

A bridge-vehicle system is considered in which a highway bridge is idealized as a lumped-mass beam and the vehicle has two axles, each with a non-linear suspension. Equations of motion are derived in terms of natural model coordinates of the bridge and displacement coordinates of the vehicle. Variation in speed consistent with applied acceleration or braking force is admitted by the inclusion of an independent coordinate defining vehicle span-wise location. The effect of braking on bridge loading is examined in two bridges of composite construction, one single span and one three span continuous. In these examples the contributions to impact factors by braking effects alone are comparable with the maximum fractional impact allowance of 0.3 commonly specified by design codes.

BUILDING

(Also see Nos. 390, 393)

78-461

Contribution of a Floor System to the Dynamic Characteristics of Reinforced Concrete Buildings

L.R. Malik and V.V. Bertero

Earthquake Engrg. Res. Center, California Univ., Berkeley, CA., Rept. No. EERC-76-30, 292 pp (Dec 1976)

PB-272 247/8GA

Key Words: Buildings, Dynamic structural analysis, Stiffness methods, Matrix methods

A practicable and sufficiently accurate stiffness matrix method for estimating the contribution of a floor system to the overall elastic stiffness of moment-resisting space frames is developed. The floor system considered consisted of a two-way reinforced concrete slab supported on beams between columns. This stiffness matrix method is achieved by performing extensive parametric finite element analyses to identify the main parameters affecting and, therefore, controlling the stiffness of individual floor panels of the floor system. Analytical tests confirm this method's accuracy in estimating the beam-slab composite action in flexible floors.

HELICOPTERS

(Also see No. 421)

78-462

Subjective Ratings of Annoyance Produced by Rotary-Wing Aircraft Noise

J.H. Patterson, Jr., B.T. Mozo, R.D. Schomer, and R.T. Camp

Army Aeromedical Research Lab., Fort Rucker, AL, Rept. No. USAARL-77-12, 36 pp (May 1977)

AD-A043 435/7GA

Key Words: Helicopter noise

Subjective ratings of annoyance caused by helicopter noise relative to that caused by fixed-wing aircraft were obtained. Comparison of the subjective ratings with various physical predictors of annoyance indicated that the integrated A-weighted level (dBA) predicted as well as any of the predictors with the D2-weighted level and EPNL almost equivalent. The B-weighted level and C-weighted level did not predict as well. No correction factor for the impulsive character (blade slap) of the helicopter noise was required. No substantial penalty for helicopters compared to fixed-wing aircraft noise was required.

HUMAN

(Also see No. 428)

78-463

An Assessment of the Relative Importance of Sources of Urban Noise

W.J. Galloway

Bolt Beranek and Newman, Inc., Canoga Park, CA 91305, Noise Control Engr., 9 (2), pp 68-73 (Sept/Oct 1977) 4 figs, 3 tables, 7 refs

Key Words: Urban noise, Human response, Noise tolerance

The author makes a preliminary analysis of a survey of over 2000 people and rank orders several noise sources in terms of the annoyance reported by the respondents.

78-464

Individual Differences in Sensitivity to Traffic Noise: An Empirical Study

I.D. Griffiths and F.R. Delauzun

Atkins Research and Development, Epsom, Surrey KT18 5BW, UK, J. Sound Vib., 55 (1), pp 93-107 (Nov 8, 1977) 11 tables, 17 refs

Sponsored by the Dept. of the Environment

Key Words: Traffic noise, Human response, Noise tolerance

Repeated interview surveys were made in suburban residential areas of London and Liverpool. In both cities two sites were selected according to the noise exposure level (70 or 80 dB(A) 18 hour L_{10}, 1 meter from dwelling facade). The characteristics of the neighborhoods were similar in all other relevant respects. Questions included noise dissatisfaction semantic differential scales, sensitivity to noise scales, environmental sensitivity scales, and classifactory questions.

ISOLATION

78-465

Parametric Optimization of a 1-DOF Vehicle Travelling on a Randomly Profiled Road

T. Dahlberg

Div. of Solid Mech., Chalmers Univ. of Technology, Fack, S-402 20 Gothenburg, Sweden, J. Sound Vib., 55 (2), pp 245-253 (Nov 22, 1977) 6 figs, 12 refs

Key Words: Vibration isolators, Single degree of freedom systems, Random excitation, Ground vehicles

This paper discusses the optimization of a passive spring-damper isolation of a linear one-degree-of-freedom system under stationary zero mean Gaussian random excitation. The mean of the maximum extrema of the acceleration is minimized at the same time as the working space of the spring and the damper is limited. The problem may be of importance in the design of road vehicles, in respect to whole-body vibrations.

METAL WORKING AND FORMING

78-466

An Estimate of the R and D Costs to Develop the Noise Reduction Technology for the Design and Fabrication of Quiet Machines Typically Used by the Fabricated Metal Products Industry

E.P. Bergmann

IIT Research Inst., Chicago, IL, Rept. No. IITRI-J6331-TR, 31 pp (Jan 1976)

PB-271 885/6GA

Key Words: Machinery noise, Noise reduction, Machine tools

This is a task report of effort directed toward a pilot study on one noise intensive industry (Fabricated Metal Products) to more clearly define the machinery noise problem of that industry, the technology available to reduce the machine noise levels, the technology that needs to be developed and the most cost/effective/beneficial means of providing federal research, development and demonstration participation. Specifically, this task was directed toward estimating the R&D costs associated with developing the noise reduction technology to allow the quiet machinery, needed by this industry, to be designed and fabricated.

78-467

An Assessment of the Machinery Noise Problem of the Fabricated Metal Products Industry

E.P. Bergmann and E.B. Ahlers

IIT Research Inst., Chicago, IL, Rept. No. IITRI-J6331-SR, 38 pp (Jan 1976)

PB-271 905/2GA

Key Words: Machinery noise, Noise reduction

This is a summary report of a pilot study on one noise intensive industry -- Fabricated Metal Products (SIC 34). The primary objective of this study was to ascertain if enough information exists in open literature and in private and public sources to allow an assessment of: the machinery noise problem of an industry; the technology available to reduce the machine noise levels; the technology that needs to be developed; the potential ability of the industry to pay for the noise reduction technology development; and the most cost/effective/beneficial means of providing federal research, development and demonstration participation.

PUMPS, TURBINES, FANS, COMPRESSORS

78-468

A Pictorial Guide to the Interpretation of Frequency Spectra - Part 2

H.J. Bickel

Nicolet Scientific Corporation, Northvale, NJ, Noise Control, Vib. and Insul., 8 (8), pp 287-290 (Oct 1977) 14 figs

Key Words: Fans, Acoustic signatures, Graphic methods

Acoustic noise and vibration of a fan provide the illustrations for this paper. A look at the octave and 1/3-octave acoustic spectrum is presented. Fine resolution (constant bandwidth) analysis is used to show many of the discrete frequencies present in the fan's acoustic 'signature'. As expected, turbulent airflow produces a noise-like signal whose average spectrum characteristics are illustrated. Later, an accelerometer is located at four different places on the fan's housing and the resulting spectra are compared.

78-469

Designing the Noise Out of Fans is Difficult but Necessary

Product Engr. (NY), 48 (11), pp 33-35 (Nov 1977)

Key Words: Fans, Noise reduction, Design techniques

Low noise fan designs are discussed in the article. Good system design can smooth air flow patterns to reduce turbulence, keep pressure down, and eliminate structural conditions that cause vibration and resonances, all of which contribute to noise reduction.

78-470

Fan Supersonic Flutter: Prediction and Test Analysis

D.G. Halliwell

Rolls-Royce Ltd., Derby, UK, Rept. No. ARC-R/M-3789; ARC-36374, 24 pp (1977)

N77-31163

Key Words: Fans, Flutter

The aerodynamic and vibration characteristics of unstalled supersonic flutter in fan assemblies having part-span shrouds or clappers are described. It is briefly compared and contrasted with stall flutter. The importance of frequency and modeshape analyses is stressed and supersonic flutter prediction methods are examined, commencing with the modeshape parameter. Unsteady work theory leads to the study of aerodynamic damping with the prediction of flutter mode, speed and wave direction. Throughout, emphasis is given to the support of design analysis by test data, from laboratory measurements on stationary models to full scale engine altitude test chamber behavior. Finally, the effect on flutter of some of the opening criteria in engine service is considered.

RAIL

78-471

Natural Frequency of Rail Track and Its Relationship to Rail Corrugation

R.I. Mair

Civ. Engrg. Trans., Instn. of Engr., Australia, 19 (1), pp 7-11 (1977) 3 figs, 5 tables, 16 refs

Key Words: Railroad tracks, Beams, Elastic foundations

Conventional approaches to the design of railroad track are based on static beam-on-elastic foundation analyses. Examinations of inelastic rail head deformation (corrugation) associated with heavy iron ore traffic show a periodic recurrence suggestive of a system resonance. An analysis is conducted to determine the dynamic vibation response of railroad track. Thermal axial loads, foundation damping and vehicle unsprung mass are taken into account. Frequency response is evaluated for a range of parameters typical of track design for heavy axle load unit train operations.

78-472

Preliminary Evaluation of Rail Vehicles by Computer Simulation

D.R. Ahlbeck

Appl. Dynamics and Acoustics Section, Columbus Battelle Labs., OH, High Speed Ground Transp. J., 11 (3), pp 281-296 (Fall 1977) 7 figs, 9 refs

Key Words: Railroad trains, Interaction: rail-wheel, Computer programs

Mathematical models of rail vehicles and track structures developed over the past decade have proven to be invaluable tools in rail transportation research. One important use of these mathematical models is to provide a preliminary evaluation of new rail vehicle and track structure designs, prior to extensive prototype construction and testing. In this paper a brief description of Battelle's linear, random vibrations rail vehicle model, Program TRKVPSD, is given. This program has in the past been used for comparative studies of different freight and passenger rail vehicles. Some

aspects of suspension parameter simulation, model validation, and modeling limitations are discussed, with comparative examples from test data and computed response for the Metroliner passenger car.

78-473

General Models for Lateral Stability Analyses of Railway Freight Vehicles

E.H. Law, J.A. Hadden, and N.K. Cooperrider
Dept. of Mech. Engrg., Clemson Univ., SC, Rept. No. FRA/ORD-77/36, 229 pp (June 15, 1977)
PB-272 371/6GA

Key Words: Freight cars, Hunting motion, Mathematical models

The report presents the development of general analytical models for use in exploring the nature of freight car hunting and for finding means of controlling the hunting behavior. A model of a wheelset with lateral, yaw, and axle torsional degrees of freedom was developed. Two such wheelsets are included in a general model of a 9 degree of freedom truck that has lateral, yaw, and warp degrees of freedom in addition to relative lateral and yaw motions of the wheelsets with respect to the truck frame. By suitable choices of primary suspension elements, this general model may be specialized to become a roller-bearing freight truck, a plain-bearing freight truck, a roller-bearing truck with primary suspension elements, a passenger truck, a generic model of a freight truck with interconnected wheelsets, or a rigid truck. Finally, two such truck models are combined with a car body that has lateral, yaw, and roll rigid body degrees of freedom plus two degrees of freedom that serve to approximate the first lateral bending and torsional modes. For all three models, the effects of design parameters on the critical speed for hunting are examined.

RECIPROCATING MACHINE

78-474

Free Dynamics and Stability of the S-S Pair of a Free Piston Engine

A.D. Dimarogonas and A. Barman
Univ. of Patras, Patras, Greece, Mech. and Mach. Theory, 12 (6), pp 593-603 (1977) 9 figs, 12 refs

Key Words: Electro-internal combustion engines, Pistons, Stability

The two opposed pistons of a new development of the free-piston engine, namely the Electro-Internal Combustion Engine, form an S-S pair which exhibits certain interesting instability phenomena. The free dynamic response of this highly nonlinear system and its stability was studied and tabulated for a wide range of parameter constellation.

78-475

Structural Vibration Noise Abatement of a Large Diesel Engine

P.K. Varma and S. Kumar
Dept. of Mech., Mechanical and Aerospace Engrg., Illinois Inst. of Tech., Chicago, IL., Rept. No. IIT-TRANS-74-1, FRA/ORD-76/273, 100 pp (July 1976)
PB-271 503/5GA

Key Words: Engine noise, Engine vibration, Noise reduction, Vibration control, Vibration isolation, Vibration damping, Composite structures

This report presents a vibration-noise investigation and a redesign of the top deck and the hand hole covers of GM 645E series railroad diesel engine for reduction of vibration and radiated noise. This was achieved by incorporating in the redesigned components, isolation, stiffening and damping. For damping, the solid friction, constrained layer and viscous air damping approaches were utilized. Experimental results on vibration and noise of the original and redesigned covers were obtained.

78-476

Truck Noise X: Noise Reduction Options for Diesel Powered International Harvester Trucks. Vol. 1. Development Work

S.T. Razzacki
Truck Engrg. Center, International Harvester Co., Fort Wayne, IN, Rept. No. DOT-TSC-OST-76-14-Vol-1, 157 pp (Apr 1977)
PB-271 091/1GA

Key Words: Noise reduction, Diesel engines, Trucks

Noise reduction option development work was carried out on two inservice diesel powered International Harvester trucks, consisting of a Cab-over model and a Conventional model with a baseline exterior noise level of 87 dB(A) each. Since no specific noise goals were set, International Harvester established an exterior noise reduction goal of 83 dB(A). Then, for each vehicle, proper noise source identification techniques were applied and major contributors were established. The commercially available source noise reducing components were tested singly, and were selected based upon an optimum evaluation.

78-477

Truck Noise X: Noise Reduction Options for Diesel Powered International Harvester Trucks. Vol. II. Cost-Noise Analysis and Field Installation

S.T. Razzacki

Truck Engrg. Center, International Harvester Co., Fort Wayne, IN, Rept. No. DOT-TSC-OST-76-14-Vol-2, 122 pp (Apr 1977)

PB-271 092/9GA

Key Words: Noise reduction, Diesel engines, Trucks

Noise reduction option development work was carried out on two inservice diesel powered International Harvester trucks, consisting of a Cab-over model and a Conventional model with a baseline exterior noise level of 87 dB(A) each. Since no specific noise goals were set, International Harvester established an exterior noise reduction goal of 83 dB(A). Then, for each vehicle, proper noise source identification techniques were applied and major contributors were established. The commercially available source noise reducing components were tested singly, and were selected based upon an optimum evaluation. The selected components were collectively installed on the trucks and cumulative performance in the total truck environment was found to be adequate to meet the established noise level goals.

ROAD

(Also see Nos. 385, 396, 397, 398, 439, 465)

78-478

Handling Characteristics of Car-Trailer Systems: A State-of-the-Art Survey

E.F. Kurtz, Jr. and R.J. Anderson

Dept. of Mech. Engrg., Queen's Univ., Kingston, Ontario, Canada, Vehicle Syst. Dyn., 6 (4), pp 217-243 (1977) 181 refs

Key Words: Cars, Trailers, Aerodynamic loads, Tire forces, Stability

A state of the art review on passenger cars towing trailers is presented. Among the topics are aerodynamic forces, tire forces, the compliance concept, relevant work on vehicles without trailers, vehicles with trailers, and the role of the driver. The types of stability problems exhibited by car-trailer systems are discussed.

78-479

Adaptation of a General Multibody Dynamical Formalism to Dynamic Simulation of Terrestrial Vehicles

R.E. Roberson

Dept. of Appl. Mech. and Engrg. Sciences, Univ. of California, San Diego, La Jolla, CA 92037, Vehicle Syst. Dyn., 6 (4), pp 279-295 (1977) 25 refs

Key Words: Ground vehicles, Digital simulation

The development of general Eulerian dynamic formalisms for the digital simulation of multibody systems is reviewed. The formalism of Robertson/Wittenburg is generalized to systems whose configuration includes closed loops, thereby adapting it to the dynamic simulation of terrestrial vehicles.

78-480

Sensitivity of Driver-Vehicle Performance to Vehicle Characteristics Revealed in Open-Loop Tests

M.C. Good

Dept. of Mech. Engrg., Univ. of Melbourne, Parkville, Victoria 3052, Australia, Vehicle Syst. Dyn., 6 (4), pp 245-277 (1977) 2 tables, 79 refs

Key Words: Ground vehicles, Steering effects, Design techniques

This paper reviews the studies that have attempted to find a relationship between closed-loop task performance, and driver subjective opinion, and various steady-state and transient characteristics revealed in open-loop tests of the vehicle.

78-481

Tire-Pavement Interface Variability. Volume II. Technical Report

G.G. Hayes

Texas A&M Research Foundation, College Station, TX, Rept. No. RF3256-Vol-2, DOT-HS-802 554, 174 pp (Aug 1977)

PB-272 289/0GA

Key Words: Interaction: wheel-pavement

To account for or eliminate the effects of surface properties on vehicle handling performance measured in established open-loop tests, various measures of surface properties were compared to vehicle test results on disparate surfaces. None of the non-vehicle textural and friction measures correlated well with vehicle performance. However, the vehicle performance was relatively insensitive to pavement properties on dry, stable surfaces. The peak 'coefficient of friction' with partial braking using a tire tester was also insensitive to pavement differences. Surfaces that produced some differences in vehicle performance also produced relatively large differences in the locked-wheel 'coefficient of friction'

obtained with a standard skid measurement system. On the pavements used, if the locked-wheel coefficient showed no significant difference between pavements, the vehicle performance measures also showed no signfiicant difference.

78-482

Development of Vehicles-In-Use Sub-Limit Maneuvers. Volume I: Summary Report

D.E. Johnston

Systems Technology, Inc., Hawthorne, CA., Rept. No. STI-TR-1064-1, DOT-HS-802 541, 37 pp (Aug 1977)

PB-271 642/1GA

Key Words: Automobiles, Steering effects, Suspension systems (vehicles), Braking effects, Tire characteristics

Automobile sub-limit performance maneuvers and measures were developed for investigating the influence of vehicle-in-use steering, suspension, and brake system degradation and tire factors on vehicle handling. The maneuvers and performance measures are directed at vehicle static and dynamic stability characteristics, vehicle controllability, driver workload, and vehicle path stability under unbalanced force or moment disturbance inputs. The NHTSA automobile simulation was modified to incorporate various steering and suspension degradations and was employed to guide selection of maneuver and component degradation levels for full-scale vehicle testing. A multi-vehicle test plan was outlined to extend the current vehicle data base, to refine the maneuvers and procedures developed in this program, and to initiate development of meaningful acceptability criteria for vehicles-in-use sub-limit performance testing.

78-483

The Overland Gully, Ramp and Step Response of the AALC JEFF (A) ACV, Model Experiments

L.O. Murray and D.D. Moran

Ship Performance Dept., David W. Taylor Naval Ship Res. and Dev. Center, Bethesda, MD, Rept. No. SPD-615-07, 41 pp (June 1977)

AD-A044 499/2GA

Key Words: Amphibious vehicles, Model testing

A series of experiments was performed to evaluate the overland behavior of the Amphibious Assault Landing Craft Program Air Cushion Vehicle designated as the JEFF (A). The experiments consisted of free passages of the craft over a series of gullies, ramps, and steps and allowing the vehicle to pitch and heave. The resultant pitch and heave response functions are presented graphically.

78-484

Overland Dynamics of the Amphibious Assault Landing Craft JEFF (B) One-Sixth Scale Model

D.D. Moran, R.F. Messale, L.O. Murray, and J.J. Ricci

Ship Performance Dept., David W. Taylor Naval Ship Res. and Dev. Center., Bethesda, MD, Rept. No. SPD-615-06, 28 pp (May 1977)

AD-A044 498/4GA

Key Words: Amphibious vehicles, Ground effect machines, Model testing

The dynamic response of the Amphibious Assault Landing Craft 1/6 scale JEFF (B) model for craft passage over gullies or ground plane indentations is presented for a series of gully lengths. The experimental results are compared with responses predicted by a static mathematical model of the JEFF (B) vertical plane response.

ROTORS

78-485

Stability of a System Consisting of Flexible Rotor and Flexibly Mounted Journal Bearings

K. Kogure and A. Tamura

Musashino Electrical Communication Lab., Nippon Telegraph and Telephone Public Corp., Musashinoshi, Tokyo, Japan, Bull. JSME, 20 (149), pp 1424-1430 (Nov 1977) 12 figs, 3 refs

Key Words: Rotor-bearing systems, Flexible rotors, Journal bearings, Stability

Stability characteristics of a system consisting of a flexible rotor and oil journal bearings mounted on flexible damped supports were investigated theoretically and experimentally. The stability conditions of the flexibly supported system without damping were derived analytically, and the effect of the support with damping on stability was calculated numerically from the Routh-Hurwitz criterion. Based on the analytical results, the effects of equivalent mass and damping of the flexible support on the stability of the flexible rotor-bearing system were investigated and the optimum design of the bearings mounted on flexible damped supports clarified. The experimental results were in good agreement with the analytical ones. Consequently, it was found possible to eliminate the oil whip phenomenon, using an appropriate support design.

78-486
Zero-Load Stability of a Rigid Rotor Supported on Pressurized Porous Gas Bearings

B.C. Majumdar
Dept. of Mech. Engrg., Indian Inst. of Tech., Kharagpur, India, Mech. and Mach. Theory, 12 (4), pp 303-310 (1977) 9 figs, 5 refs

Key Words: Rotor-bearing systems, Gas bearings, Whirling

A theoretical and experimental investigation of stability characteristics of a rigid rotor mounted on externally ex-pressurized gas-lubricated porous bearings is made. The hydrodynamic fluid film forces of an unloaded journal which undergoes steady whirl are obtained to find limits of the stable region. The results are compared with experimental data and with a similar solution using Galerkin's method. The effect of a feeding parameter, supply pressure, thickness of porous bushing and porosity of bushing material on stability characteristics is also investigated.

78-487
Stability Behaviour of Finite MHD Journal Bearings

P.A. Kulkarni and B.V.A. Rao
Dept. of Mech. Engrg., Walchand College of Engrg., Sangli 416415, India, Mech. and Mach. Theory, 12 (4), pp 293-302 (1977) 5 figs, 12 refs

Key Words: Rotor-bearing systems, Journal bearings, Magnetohydrodynamics, Stability

The instability of a rigid rotor supported on MHD journal bearings under the influence of an axial magnetic field and a radial electric field is theoretically analyzed in this paper. The MHD Reynolds' equation is solved by using the finite element method and stiffness and damping coefficients are obtained. The stability is determined by Routh's criteria.

78-488
Synchronous Steady State Response of an Overhung Rotor with Squeeze Film Damping

R.W. Shende
Dept. of Aeronautical Engrg., Indian Inst. of Tech., Bombay-400 076, India, Mech. and Mach. Theory, 12 (4), pp 281-291 (1977) 8 figs, 10 refs

Key Words: Rotors, Squeeze-film dampers, Computer programs, Whirling

An analytical method is developed for treatment of a typical system in which the outrigger bearing of an overhung rotor is provided with a squeeze film damper supported in a flexible casing. The rotor and stator of multiple degrees-of-freedom are handled with convenience by a "polar receptance matrix" method. A characteristic equation is derived which governs rotor-stator interaction either with dry contact or through a squeeze film damper. For the nonlinear squeeze film action solutions based on "mobility" information of a dynamically loaded journal bearing are obtained facilitating a general approach. A computer program is written in Fortran for steady state response of the system in terms of whirl, position and force vectors, trial runs of which indicate complex behavior of a squeeze film damped system.

78-489
Rotor-Bearing Dynamics - State-of-the-Art

N.F. Rieger
Dept. of Mech. Engrg., Rochester Inst. of Tech., Rochester, NY 14623, Mech. and Mach. Theory, 12 (4), pp 261-270 (1977) 81 refs

Key Words: Rotor-bearing systems, Reviews, Computer programs, Balancing techniques, Stability, Torsional response

The purpose of this paper is to indicate certain important publications which have recently appeared on the following aspects of rotor-bearing dynamics: computer programs, balancing, stability, and torsional dynamics of rotor systems. Attention is also drawn to a number of important remaining problems.

78-490
Finite Element Analysis of Rotors

A.V.K. Murty and S.S. Murthy
Dept. of Aeronautical Engrg., Indian Inst. of Science, Bangalore 560012, India, Mech. and Mach. Theory, 12 (4), pp 311-322 (1977) 3 figs, 4 tables, 10 refs

Key Words: Rotors, Variable cross section, Natural frequencies, Finite element technique

A finite element formulation for the natural vibration analysis of tapered and pretwisted rotors has been presented. Numerical results for natural frequencies for various values of the geometric parameters and rotational speeds, have been computed for the case of rotors with and without pretwist. A Galerkin solution for the fundamental has also been worked out and has been used to provide a comparison for the finite element results. Charts for rapid estimation of the fundamental frequency parameter of tapered rotors, have been included.

78-491

The Effect of Flexible Appendages on Shaft Whirl Stability

F.J. Wilgen

Ph.D. Thesis, The Univ. of Wisconsin-Madison, 122 pp (1977)

UM 77-19,132

Key Words: Shafts, Whirling

This investigation examines the effect of appendage flexibility on shaft whirl stability. A theory is developed, based on the method of Liapunov, sufficiently general to obtain stability criteria for shaft-appendage systems comprising any number of flexible continuous appendages. Two models consisting of a flexible continuous disk appendage and a flexible continuous beam appendage located at an arbitrary position on a flexible continuous shaft are examined in detail. Stability boundaries are presented as functions of the appendage flexibility parameter. These boundaries reduce to the the case of a shaft containing a concentrated mass at the point of appendage attachment when the appendage stiffness is small, and approach the case of a shaft with a rigid appendage as the stiffness increases.

78-492

Propeller Study. Part 2: The Design of Propellers for Minimum Noise

A.I. Ormsbee and C.-J. Woan

Dept. of Aeronautics and Astronautical Engrg., Illinois Univ., Urbana, IL, Rept. No. NASA-CR-155005; AAE-77-13-Pt-2; UILU-ENG-77-0513-Pt-2, 203 pp (July 1977)

N77-31157

Key Words: Propellers, Noise reduction, Design techniques

The design of propellers which are efficient and yet produce minimum noise requires accurate determinations of both the flow over the propeller. Topics discussed in relating aerodynamic propeller design and propeller acoustics include the necessary approximations and assumptions involved, the coordinate systems and their transformations, the geometry of the propeller blade, and the problem formulations including the induced velocity, required in the determination of mean lines of blade sections, and the optimization of propeller noise. The numerical formulation for the lifting-line model are given. Some applications and numerical results are included.

SHIP

78-493

Design of a High Speed Single-Screw Containership

H. Langenberg and G.O. Andersson

Instn. Mar. Engrs., Trans., 9, Ser. A, Pt. 5, pp 163-199 (1977) 17 figs, 5 tables, 16 refs

Key Words: Cargo ships, Containers, Propeller-induced excitation, Design techniques

The authors show that propeller excited vibrations are a main problem in single screw containerships - it must be considered in the early stage of design and given the same importance as speed and stability. This is the lesson they learned from the production of six of these ships which have low vibrations levels. Both model and full scale measurements substantiate this statement. Additional investigations on potential future containership designs have been carried out and the authors conclude that the fast single screw containership of limited size is likely to become the ship of the early eighties.

78-494

The Uses of Viscoelastic Materials for Noise Reduction on Ships

J. Asztely

Becker-Akustic, Sweden, Noise Control, Vib. and Insul., 8 (8), pp 297-299 (Oct 1977) 5 figs

Key Words: Ships, Noise reduction, Viscoelastic damping

Practical experience with viscoelastic material on ships has shown that significant noise reduction can be achieved. It is done by means of constrained layer construction or a so-called sandwich construction with a thin constraining layer. The constraining layer should have a thickness that is ¼ of the thickness of the plate that is going to be damped, providing that both are made of the same material, for example, steel. The costs will be radically reduced if another stiff material is used as a constraining layer, for example, ordinary sprayed concrete.

78-495

Attenuation of Structure-Borne Sound in Superstructures on Ships

A.C. Nilsson

Research Div., Det norske Veritas, P.O. Box 300, N-1322 Hoevik, Norway, J. Sound Vib., 55 (1), pp 71-91 (Nov 8, 1977) 8 figs, 1 table, 13 refs

Key Words: Tanker ships, Ships, Noise reduction

The propagation of structure-borne sound in superstructures typical for medium-sized tankers is investigated. It is found

that the attenuation of structure-borne sound is sufficiently well described by a simple flexural wave model. Predicted results are compared to measurements made on two tankers. The attenuation of structure-borne sound is found to be a function of frequency and of material parameters and dimensions of the structure. The influence of longitudinal waves is also discussed. The model could be adapted to any type of building structure.

SPACECRAFT

78-496

A Simulation Study of a Twelve Degree of Freedom System

E.B. Hartnett

Boston College, Chestnut Hill, MA, Rept. No. Scientific-1, AFGL-TR-77-0061, 14 pp (Mar 1977)

AD-A044 756/5GA

Key Words: Suspension systems (missiles), Mathematical models

A twelve degree of freedom model for a missile suspension system was simulated mathematically. The derived equations of motion were solved for missile accelerations and displacements at various driving forces, frequencies, and damping coefficients. The simulation results were validated using measured field data.

78-497

Experimental Investigation of the Vibration Characteristics of a Model of an Asymmetric Multielement Space Shuttle

U.J. Blanchard

Langley Res. Center, NASA, Langley Station, VA., Rept. No. NASA-TN-D-8448; L-11211, 114 pp (Sept 1977)

N77-31538

Key Words: Space shuttles, Model testing

Vibration investigations of a model of the asymmetric multielement space shuttle were made. The influence on overall motions of local deformation in the vicinity of element interfaces, high modal density, low structural damping, and high responsiveness in the crew cabin are included in the findings. Mode frequencies generally increase with decreasing propellant masses and staging of elements.

STRUCTURAL

78-498

Field Dynamic Studies of a Long-Span Sign Structure

H.D. Nix and H. Reinl

Div. of Structures, California State Div. of Highways, Sacramento, CA., Rept. No. CA-HY-ST-4173-74-1, FHWA/RD-77-S0632, 50 pp (Dec 1973)

PB-271 468/1GA

Key Words: Traffic sign structures, Wind-induced excitation, Computer programs

A field study of a long-span, tubular signal bridge, very susceptible to wind-induced vibration, is described. Portions of a theoretical analysis performed by a recently developed computer program for the evaluation of 'Wind Effects on Luminaires and Traffic Signals' were verified by field testing. The predicted resonant frequencies and lowest critical wind velocity - that wind velocity which will cause structure resonance - were confirmed by the tests. An in-situ value of structure damping, 0.2% of critical damping, was measured.

AUTHOR INDEX

CALENDAR

MARCH 1978

25-27 **Applied Mechanics Western and J.S.M.E. Conference,** Honolulu, Hawaii ***(ASME Hq.)***

APRIL 1978

3-5 **Structures, Structural Dynamics and Materials Conference,** [ASME] Bethesda, MD ***(ASME Hq.)***

9-13 **Gas Turbine Conference & Products Show,** [ASME] London ***(ASME Hq.)***

17-20 **Design Engineering Conference & Show** [ASME] Chicago, IL ***(R.C. Rosaler, Rice Assoc., 400 Madison Ave., New York, NY 10017)***

17-20 **24th Annual Technical Meeting and Equipment Exposition** [IES] Fort Worth, TX ***(IES Hq.)***

24-28 **Spring Convention** [ASCE] Pittsburgh, PA ***(ASCE Hq.)***

MAY 1978

4-5 **IX Southeastern Conference on Theoretical and Applied Mechanics** [SECTAM] Nashville, TN ***(Dr. R. J. Bell, SECTAM, Dept. of Engrg. Sci. & Mech., Virginia Polytechnic Inst. & State Univ., Blacksburg, VA 24061)***

8-10 **Inter-NOISE 78,** San Francisco, CA ***(INCE, W. W. Lang)***

8-11 **Offshore Technology Conference,** Houston, TX ***(SPE, Mrs. K. Lee, Mtgs. Section, 6200 N. Central Expressway, Dallas, TX 75206)***

14-19 **Society for Experimental Stress Analysis,** Wichita, KS ***(SESA, B. E. Rossi)***

16-19 **Acoustical Society of America, Spring Meeting,** [ASA] Miami Beach, FL ***(ASA Hq.)***

JUNE 1978

30 **Eighth U.S. Congress of Applied Mechanics,** [ASME] Los Angeles, CA ***(ASME Hq.)***

SEPTEMBER 1978

24-27 **Design Engineering Technical Conference,** [ASME] Minneapolis, MN ***(ASME Hq.)***

OCTOBER 1978

8-11 **Diesel and Gas Engine Power Conference and Exhibit,** [ASME] Houston, TX ***(ASME Hq.)***

8-11 **Petroleum Mechanical Engineering Conference,** [ASME] Houston, TX ***(ASME Hq.)***

17-19 **49th Shock and Vibration Symposium,** Washington D.C. ***(H. C. Pusey, Director, The Shock and Vibration Info. Ctr., Code 8404, Naval Res. Lab., Washington, D.C. 20375 Tel. (202) 767-3306)***

17-19 **Joint Lubrication Conference,** [ASME] Minneapolis, MN ***(ASME Hq.)***

NOVEMBER 1978

26-Dec 1 **Acoustical Society of America, Fall Meeting,** [ASA] Honolulu, Hawaii ***(ASA Hq.)***

DECEMBER 1978

10-15 **Winter Annual Meeting,** [ASME] San Francisco, CA ***(ASME Hq.)***

JUNE 1979

11-15 **Acoustical Society of America, Spring Meeting,** [ASA] Cambridge, MA ***(ASA Hq.)***

CALENDAR ACRONYM DEFINITIONS AND ADDRESSES OF SOCIETY HEADQUARTERS

AFIPS:	American Federation of Information Processing Societies 210 Summit Ave., Montvale, NJ 07645
AGMA:	American Gear Manufacturers Association 1330 Mass. Ave., N.W. Washington, D.C.
AHS:	American Helicopter Society 1325 18 St. N.W. Washington, D.C. 20036
AIAA:	American Institute of Aeronautics and Astronautics, 1290 Sixth Ave. New York, NY 10019
AIChE:	American Institute of Chemical Engineers 345 E. 47th St. New York, NY 10017
AREA:	American Railway Engineering Association 59 E. Van Buren St. Chicago, IL 60605
AHS:	American Helicopter Society 30 E. 42nd St. New York, NY 10017
ARPA:	Advanced Research Projects Agency
ASA:	Acoustical Society of America 335 E. 45th St. New York, NY 10017
ASCE:	American Society of Civil Engineers 345 E. 45th St. New York, NY 10017
ASME:	American Society of Mechanical Engineers 345 E. 47th St. New York, NY 10017
ASNT:	American Society for Nondestructive Testing 914 Chicago Ave. Evanston, IL 60202
ASQC:	American Society for Quality Control 161 W. Wisconsin Ave. Milwaukee, WI 53203
ASTM:	American Society for Testing and Materials 1916 Race St. Philadelphia, PA 19103
CCCAM:	Chairman, c/o Dept. ME, Univ. Toronto, Toronto 5, Ontario, Canada
ICF:	International Congress on Fracture Tohoku Univ. Sendai, Japan
IEEE:	Institute of Electrical and Electronics Engineers 345 E. 47th St. New York, NY 10017
IES:	Institute of Environmental Sciences 940 E. Northwest Highway Mt. Prospect, IL 60056
IFToMM:	International Federation for Theory of Machines and Mechanisms, US Council for TMM, c/o Univ. Mass., Dept. ME Amherst, MA 01002
INCE:	Institute of Noise Control Engineering P.O. Box 3206, Arlington Branch Poughkeepsie, NY 12603
ISA:	Instrument Society of America 400 Stanwix St. Pittsburgh, PA 15222
ONR:	Office of Naval Research Code 40084, Dept. Navy Arlington, VA 22217
SAE:	Society of Automotive Engineers 400 Commonwealth Drive Warrendale, PA 15096
SEE:	Society of Environmental Engineers 6 Conduit St. London W1R 9TG, UK
SESA:	Society for Experimental Stress Analysis 21 Bridge Sq. Westport, CT 06880
SNAME:	Society of Naval Architects and Marine Engineers, 74 Trinity Pl. New York, NY 10006
SPE:	Society of Petroleum Engineers 6200 N. Central Expressway Dallas, TX 75206
SVIC:	Shock and Vibration Information Center Naval Research Lab., Code 8404 Washington, D.C. 20375
URSI-USNC:	International Union of Radio Science - US National Committee c/o MIT Lincoln Lab., Lexington, MA 02173

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78